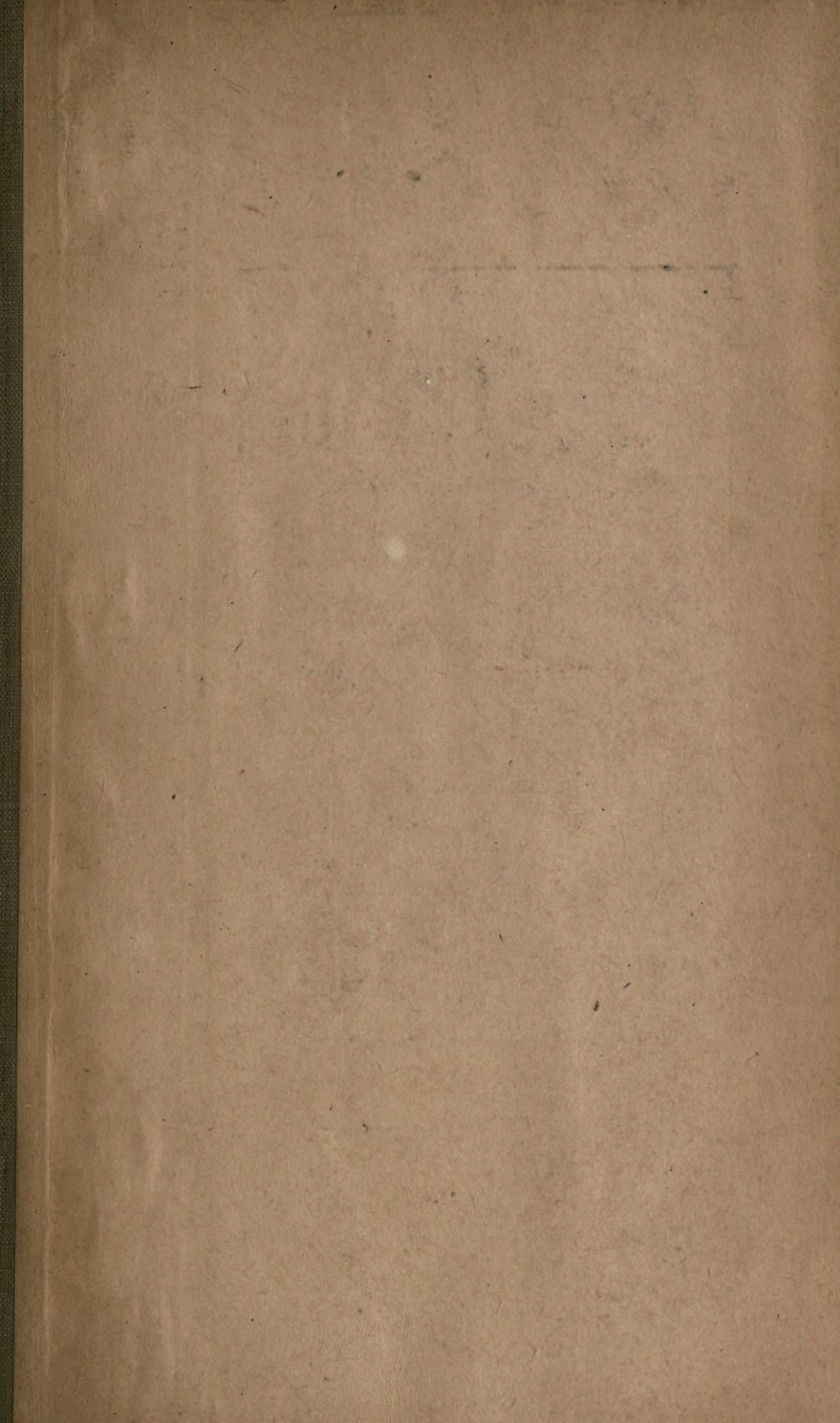


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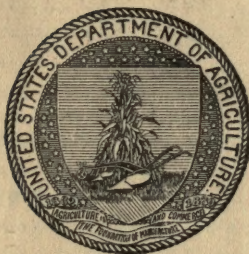
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Nos. 951-975,

WITH CONTENTS AND INDEX.

PREPARED UNDER THE SUPERVISION OF

EDWY B. REID,

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HOG PASTURES FOR THE SOUTHERN STATES

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Bureau of Animal Industry



Sows Carried on Permanent Pasture with a Little Grain in Addition

FARMERS' BULLETIN 951

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry

WM. A. TAYLOR, Chief

and the

Bureau of Animal Industry

JOHN R. MOHLER, Chief

Washington, D. C.

May, 1918

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Division of Publications, United States Department of Agriculture

GREEN FORAGE is essential to the economical production of pork.

A permanent pasture supplemented with quick-growing, heavy-yielding, temporary forage crops is most satisfactory.

There should be on an average 1 acre of permanent pasture for each brood sow kept.

Some of the heavy-yielding, quick-growing forage crops will add considerable feed to the quantity produced by a permanent pasture.

There should be mature crops, such as corn, soy beans, peanuts, or velvet beans, for finishing the hogs in the fall. Oats, rye, and wheat give satisfactory winter grazing.

Green forage alone is little better than a maintenance ration. Where rapid gains are desired, the hogs should have a liberal allowance of grain. The rule should be, all the grain they will eat without waste.

Woven-wire hog fencing tacked to stakes makes the best temporary fence.

Growing forage crops and grazing them off on the land is an efficient method of improving soils depleted in organic matter.

The exercise obtained in grazing exerts a beneficial influence on the health of hogs.

HOG PASTURES FOR THE SOUTHERN STATES.¹

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FORAGE-CROP PASTURES.

THE FARMER who provides pasture for his hogs whenever possible is the one who makes the production of pork most profitable. The raising of rapid-growing, heavy-yielding forage crops to be fed green to live stock, instead of depending upon the ordinary pasture plants, has been advocated in the United States for more than a hundred and fifty years. Some farmers appreciate the value of forage crops and have worked out the problem of crop production and utilization in a most satisfactory manner.

It is not difficult to outline a succession of crops based on the usual data of seeding, maturing, and average yields which will furnish forage on a given area of land for a certain number of hogs. It has been demonstrated that a greater quantity of forage may be secured on the same area by such a system than will be produced by the ordinary grass or grass and clover permanent pastures. While these systems have been strongly advocated for so many years, rarely is a farmer found practicing such a system.

It must be borne in mind that farmers are operating much of the time under extreme rather than average conditions. Periods of

¹For matters pertaining to the general care of hogs, the prevention of diseases, the eradication of parasites, etc., the reader is referred to Farmers' Bulletin 874, entitled "Swine Management," by George M. Rommel and F. G. Ashbrook, copies of which, together with the other Farmers' Bulletins mentioned in this publication, may be obtained free from the Division of Publications, United States Department of Agriculture.

drought frequently follow seasons of excessive rainfall, and crop failure from any cause interferes seriously with a complicated succession of forage crops. The great variability of different soils also makes a system based on average yields impracticable. Such yields are misleading, alike for soils which are very rich and for those which are poor in fertility; and, moreover, it is impossible to outline a complete succession of cultivated forage plants covering the entire year without including some very inferior sorts or else using some crops that will give greater value if harvested and sold than if grazed by hogs. The problem for hog raisers to solve is to combine dependable permanent pastures with the heavy-yielding temporary forage crops, in order to avoid periods when no green forage is available. The profits from a season's grazing are often sacrificed in a few weeks when the hogs have to be maintained entirely on high-priced commercial feeds.

VALUE OF GREEN FORAGE FOR HOGS.

The prevailing prices of the various commercial feedstuffs and pork do not justify the raising of hogs on grain or mill feeds alone. From the results of many feeding trials with hogs 10 pounds of gain for each bushel of corn fed, or 1 pound of gain for every 5.6 pounds of corn, is all that should be expected from feeding corn alone in a dry lot. A mixture of one part tankage and nine parts corn gives much better results, usually producing 1 pound of gain for every 4.5 pounds of the mixture fed. It is easy to see that farmers must get more than the customary market prices for hogs or pay less than the usual prices for these feeds in order to stand the risk of loss of animals by disease and to pay the labor and feed bills.

The quantity of grain needed to produce a pound of gain is considerably lessened if the hogs have access to green forage. Corn fed to growing shotes on rape should produce 1 pound of gain for every 3.67 pounds of grain fed. The addition of some highly concentrated feed, such as tankage, meat meal, shorts, or linseed meal, should reduce by one-half to three-fourths of a pound the quantity of grain necessary to produce a pound of gain. These figures are based on the averages of a number of feeding trials at several agricultural experiment stations. They were made with improved breeds of hogs. Equally good results should not be expected from unimproved stock, commonly spoken of as "razorbacks." While the data are somewhat conflicting, apparently as good results as those given above may be obtained while feeding hogs on any nonleguminous green forage crop which the hogs eat as readily as they do rape. The clovers and alfalfa furnish better hog pasture than the non-legumes.

GRAIN RATION FOR HOGS ON PASTURE.

The cost of pork is reduced materially by the use of pasture and forage crops, but it is desirable to feed some grain in addition. In certain sections of the country where the pastures are luxuriant, mature hogs are maintained in an apparently satisfactory condition on pasture alone. The practice should not be followed in the case of young, growing pigs, because they will become thin and stunted if compelled to live on pasture alone. Hog raisers differ widely regarding the quantity of grain that should be fed to hogs while on pasture. Some feeders give the hogs all the grain they will consume. Others feed a daily ration equal to about 2 or 3 per cent of the live weight of the hog. Still others allow pigs to run on pasture, feeding a 1 per cent grain ration.

Hogs are omnivorous animals, but they are not able to eat sufficient green forage to produce satisfactory gains without some grain. The gains are too slow to be economical. The hog should be considered as a machine for turning feedstuffs into pork. The more quickly this result can be accomplished the more profitable it is for the owner. It is a common belief that if the grain fed to hogs on pasture is limited, more forage will be eaten and cheaper gains produced. This belief is not substantiated by the feeding tests that have been conducted at several agricultural experiment stations. A full feed of grain to hogs on good pasture not only produces the most rapid gains, but usually gives the most profitable results. When account is taken of the saving of labor and the reducing of loss from disease by marketing animals at 7 to 9 months of age instead of keeping them for a year or more, the advantage is almost always with the more rapid growth. The self-feeder system which permits hogs to eat grain at will either in pastures or dry lots is becoming more and more popular in the corn-belt States, and there seems to be no valid reason why self-feeders should not prove equally successful in the South. Some hog raisers build a crib or bin in the pasture field in which they store a quantity of grain, to avoid the daily hauling of grain to the hogs. (Fig. 1.)

A distinction should be made between such forage crops as soy beans, cowpeas, peanuts, and velvet beans, which are hogged off when the seed is mature or nearly mature, and green forage, such as oats, chufas, sweet potatoes, and clover. With the former not so much grain is needed, and what is fed, usually corn, is merely to balance the ration, while with the latter a well-balanced grain ration gives the best results. The self-feeder may be used safely, however, with all crops. Healthy hogs that have as much feed as they will consume give good returns for all they eat.

The foregoing statements apply to growing hogs which are to be marketed for pork. Mature brood sows, where no great increase of weight is desired, are often kept on green forage alone, except those with suckling pigs. Gilts and sows with suckling pigs should receive in addition to the forage a grain ration of such quantity as they will clean up readily when fed two or three times a day.

Under most conditions in the South corn will form the basis of a grain ration. This should be mixed with some protein food. Half corn and half shorts make a desirable grain ration for hogs on pasture, and so do seven to nine parts of corn and one part of tankage, or two parts of corn and one part of cowpea or soy-bean meal.



FIG. 1.—Feeding time on a permanent pasture. Note the crib for storing corn.

These mixtures are merely suggestive, as there are a large number of other good feeds the use of which may be more desirable, depending upon the prevailing prices.

PERMANENT PASTURES.

The importance of having a good permanent pasture for hogs can hardly be overestimated. In many hog-producing localities no other green forage is used than that furnished by grass or grass and clover pastures. The advantage of not having to go to the expense of frequently preparing and seeding the land appeals to most farmers.

The best permanent pastures in the Southern States consist of a mixture of Bermuda grass, lespedeza, bur clover, and white clover. Black medic is useful also in Bermuda-grass pastures, as it reseeds itself the same as bur clover and lespedeza. Alfalfa and sweet clover may be considered as permanent pasture plants in the localities where they grow readily. Carpet grass¹ will thrive better than Bermuda

¹ *Axonopus compressus*.

grass in the sandy soils along the Gulf, and St. Augustine grass,¹ which is very similar to carpet grass in habit of growth, seems best suited to the Atlantic coast south of Charleston, S. C. These permanent pastures may be improved by a little attention in the fall. Disking the sod and seeding to either rye-grass, bur clover, white clover, or narrow-leaf vetch, or some combination of them, will add to the winter grazing of a Bermuda-grass or carpet-grass pasture. The clovers and vetch usually volunteer for several seasons, so this seeding may not have to be repeated every fall. The subject of permanent pastures is considered in a circular issued on December 23, 1914, entitled "Permanent Pastures for the Cotton Belt," a copy of which may be obtained without cost from the Division of Publications, United States Department of Agriculture.

CARRYING CAPACITY OF PASTURES.

Hogs do not relish grasses except when the leaves are young and tender. Hence it is necessary for the best results to keep permanent pastures well stocked. If the plants are allowed to mature, they not only become less palatable but are deficient in feeding value as well. It is usually advisable to have some other stock in the pastures with the hogs to eat the coarser plants. Cattle are best suited for this purpose. Mowing the pasture in late spring should be practiced if the plants become too far advanced.

It is impossible to state how many animals per acre will be supported by a permanent pasture. In most cases it is advisable to have some of the best supplementary forage crops to graze in addition to the pasture. A safe rule is to have a least 1 acre of good permanent pasture for each brood sow kept. Of course, this acreage could be reduced or the number of hogs increased where a complete succession of supplementary forage crops is raised or where the land is very productive. A greater area should be allowed if the grazing is poor.

The carrying capacity of the various supplementary forage crops varies widely, according to the growth of the crop. As a rule it is safe to graze them at the rate of ten to fifteen 100-pound shotes to the acre. A greater number will shorten the grazing period, and fewer animals will lengthen it.

EFFECT OF GRAZING ON THE SOIL.

Growing forage crops and grazing them with hogs are very efficient and economical methods of improving run-down land. This statement is based on the opinions and results of a large number of hog raisers and experiment-station workers. Practically all the fer-

¹ *Stenotaphrum americanum*.

tilizing elements of the vegetation produced on the land, except that stored in animal bodies, goes back into the soil in the manure and litter. The loss is more than offset where extra grain is fed to the hogs. The only danger of injury to the soil is in the trampling by the animals on heavy clays when they are wet. Such injury is easily avoided where a permanent sod pasture is available.

As one of the great needs of most southern soils is more vegetable matter, hog grazing offers an opportunity of restoring the exhausted humus without the expense of growing and using green-manuring crops. Another benefit, which is usually overlooked, comes from the hogs eating the weeds in the pasture fields. There are many common plants, usually classed as weeds, which hogs relish. The common lamb's-quarters and amaranths are especially palatable to hogs. They frequently clean these up first when turned into a new field. This not only makes good use of a number of waste plants, but also tends to lessen the trouble from these weeds in other crops.

TEMPORARY FENCES.

It is often desirable in hog pasturing to fence off portions of fields temporarily. A great many different types of temporary fences have been devised. Most of the board fences of the panel type are too heavy and cumbersome to be practicable. They are also easily broken and soon rot. About the best temporary hog fence is made of 32-inch or 36-inch woven wire. This is easily stretched and tacked to stakes driven in the ground. It may also be used in fencing off parts of a cornfield which are to be hogged off by merely tying the fence to a row of cornstalks. When this is done the tops and ears of the row of corn to which the fencing is tied should be broken off, as then the hogs will not climb up the fence.

Well-fed hogs are easily kept in place, but underfed ones will require more substantial fencing than is here described.

FORAGE CROPS FOR HOGS.

There are a large number of valuable hog forages which may be grown in the South. Every farmer who attempts hog raising on an extensive scale should grow some of these in addition to his permanent pasture. It is possible by the proper selection of crops to have good green forage during all seasons of the year. While the crops considered in this bulletin are not all that might be grown for hog pastures, they are the ones which experience has proved to be the best. Most of these crops may be seeded broadcast, but there is less waste when grazed if they are in rows. The hogs will walk in the space between the rows without trampling down the vegetation, as they do when a crop is broadcasted.

CORN.

The corn crop is so well known and its value for producing a fine quality of meat so well understood that it needs no discussion. The fact that hogs will harvest the corn crop as economically as the farmer will is not so well understood. Hogging off corn has been tested thoroughly at several agricultural experiment stations and by practical hog raisers, and the practice is strongly recommended. Corn alone is not a satisfactory hog ration. Where the crop is to be hogged off, some other crop should be combined with it. Pumpkins seeded at the same time as the corn, soy beans or cowpeas seeded in the same or in alternate rows with the corn, and rye, rape, or soy beans seeded at the last working of the corn have all been used with satisfactory results. The velvet-bean and corn combination is considered under "Velvet beans." With one of these combinations no other grain ration is needed, but if there is no other forage growing in the cornfield, some concentrate, such as tankage, cowpea meal, or middlings, should be fed. It is advisable to start the hogs gradually, for a few days, with a little green corn before turning them into a field of corn to hog it off. The corn is ready for grazing when the grain is dented or glazed. It will take about one month for 14 to 16 hogs, weighing 150 pounds each, to hog off an acre of corn which would yield 35 bushels. It is not advisable to let the hogs have access at any one time to more than they will clean up in 10 days.

SORGHUM.

Sorghum is not a good forage crop for hogs. Young growing shoters will just about maintain their weights while grazing on green sorghum alone, but fat hogs will lose weight unless some grain is fed along with the sorghum. This crop, however, may be used to fill a gap in midsummer, when it is difficult to find anything else that is better. It is better to have sorghum than no green crop for grazing. Farmers with plenty of Bermuda-grass-lespedeza pasture may well depend upon that rather than grow sorghum for hog grazing.

When sorghum is 15 to 24 inches high hogs will eat the entire plant, but later, when the plants are older, they chew the stalks, suck the juice, and spit out the fibrous material. An early variety of cowpeas is often grown with the sorghum. This adds much to the feeding value of the crop.

If used for hog pastures, sorghum may be seeded in rows or drilled broadcast. From 8 to 10 pounds of seed will seed an acre in rows, while 40 pounds is needed for broadcast seedings. One of the best ways of broadcast seeding is to use a grain drill with all the holes running. The crop should be ready for grazing about six weeks after seeding. A good crop of sorghum can be grazed for about two months, if stocked at the rate of 12 to 15 hogs to the acre.

WINTER GRAINS.

Wheat, rye, and oats are often used for hog grazing in the South. They may be seeded after a crop of soy beans, cowpeas, or peanuts has been grazed off. The winter grazing afforded by these crops is about equal to that obtained from a crop like artichokes which has taken an entire season to grow. It matters little which one of these grains is used; in fact, some farmers seed a mixture of any two or all three together where the crop is to be grazed. Green oats are more palatable to hogs than either rye or wheat, and rye appears to be slightly more palatable than wheat, but hogs will readily graze wheat when no other green forage is available. If not grazed too late in the spring, a crop of grain will also be produced. Some prefer to graze during the early spring months and then put the land in corn or some other summer crop. The hogs may be taken from oats when growth starts in the spring and turned back on the field after the oats have headed out and the grain is in the dough stage. About two weeks' additional grazing is usually obtained from this second period.

Grazing ripe wheat or rye, as sometimes practiced, has little to recommend it. Experiments to test the feeding value of unthrashed wheat or rye have seldom shown results favorable to the practice. A crop of wheat is worth more to harvest and sell for grain than it is for hog forage unless the price of wheat is extremely low and that of pork relatively high. The thrashed grain of wheat or rye is a little more valuable, bushel for bushel, than corn for feeding hogs.

Grinding the wheat or rye and feeding it in the form of a slop adds from one-sixth to one-fourth to the feeding value of the grain. It appears from the experimental data on the subject that it would be more profitable to thrash and grind the wheat or rye than to graze the unthrashed crop.

ALFALFA.

Alfalfa is perhaps the best of all green forages for hogs. It starts growth early in the spring. If kept moderately grazed or if mowed at intervals it keeps green all summer. In the South alfalfa will not stand close grazing with hogs. If grazed, sufficient acreage should be allowed so that at least one, and preferably two, cuttings for hay may be made each season. Such light grazing does not seem to injure the stand. Alfalfa is very palatable to hogs and highly nutritious. Unfortunately, it does not do well on all kinds of soils. Its culture, however, is being extended in the South, especially in central Tennessee, northwestern South Carolina, on the limestone soils of western Alabama and eastern Mississippi, on some of the better drained sugarcane lands of Louisiana, and in the Black-Lands region of Texas.

The high price of alfalfa hay in the South makes it questionable whether it is better to graze this crop with hogs or make it into hay. Some tests which have been conducted, the results of which have never been published, show a greater profit from the hay than from hogs grazed on an equal area. The relative prices of hay and pork should decide this matter.

With corn at 70 cents a bushel and alfalfa pasture at \$5 an acre, it cost an average of \$3.73 a hundred pounds of gain to produce pork at the North Platte substation in Nebraska. These results covered a large number of feeding tests, including experiments with 1,345 different hogs. The value of the alfalfa eaten per hundred pounds of gain was fixed at 72 cents. As the yearly allowance for alfalfa was placed at \$5 an acre and alfalfa hay at \$8 a ton in the computations referred to, it is apparent that these valuations should be at least doubled to make them conform to southern conditions. Even with this higher price for alfalfa there should be a good profit from grazing hogs at the present (1918) prevailing prices of pork.

For detailed directions in regard to the culture of this crop, see Farmers' Bulletin 339, entitled "Alfalfa."

BLACK MEDIC AND HOP CLOVER.

Black medic is attracting considerable attention in the Black Prairie section of western Alabama and Mississippi. It is a legume similar in some respects to alfalfa. It is low growing and furnishes excellent grazing in the winter and early spring. Hogs eat it readily. It is an annual crop, but usually reseeds itself. The seed is very similar to that of alfalfa and formerly was often used to adulterate it. Its best use is probably in combination with Bermuda grass and lespedeza in a permanent pasture, as it starts growth much earlier in the spring than those two plants. There are no data to show whether or not it has any advantages over bur clover or white clover. Seed of this plant is seldom on the market in the United States, though it could be obtained easily if the demand justified its being established on a commercial basis. A start may be made by cutting the ripe plants from waste places and scattering them over the pasture fields.

Another weedy legume which seems to have some merit for permanent pastures in the South is low hop clover.¹ Its seed also is not on the market. This plant is liable to be mistaken for lespedeza, but it starts growth early in the spring and has a yellow blossom, while lespedeza makes a slow growth in the spring and has a purple flower. These, together with bur clover and lespedeza, may be considered as permanent pasture plants as well as temporary forages.

¹ *Trifolium procumbens*.

They are valuable to grow with Bermuda grass, and the black medic may be mixed with or used as a substitute for crimson clover as a catch crop for late summer seeding.

RED CLOVER.

In several localities in Tennessee and the limestone regions of the cotton belt red clover grows luxuriantly. Where this crop can be grown successfully little other forage is needed for hogs from spring to fall. If kept grazed to a height of 5 or 6 inches it remains green and in a good growing condition during the hot summer months, but if it is allowed to bloom red clover matures in early June and then languishes until late summer. Grazing should start as soon as the clover is 4 or 5 inches high and should be sufficiently heavy to prevent the plants from blooming. If the clover grows too fast and there is danger of its heading out, one of three things should be done: (1) Turn on more animals, (2) restrict the hogs to a lesser acreage and cut the rest of the clover for hay, or (3) run over the entire field with a mowing machine with the cutter bar carried 4 or 5 inches above the ground. The third plan is perhaps best, in order to insure sufficient grazing for the growing hogs during the hot months of summer.

The common red or June clover is better for hog pasture than the mammoth or sapling variety which is usually grown in the South for hay. Clover will stand grazing at the rate of 10 to 12 hogs to the acre.

Clover may be seeded for hog pastures the same as for hay. It is not advisable to seed in a mixture with grass unless the field is intended for a permanent pasture. Late summer or early fall seeding usually gives better results than spring seeding. Where red clover grows well it may be seeded in corn at the last cultivation or it may be seeded immediately after the corn is harvested. From 10 to 12 pounds of seed to the acre are sufficient.

For further information in regard to the culture of this crop, see Farmers' Bulletin 455, entitled "Red Clover."

CRIMSON CLOVER.

Much attention has been given crimson clover on account of its value as a winter cover crop. Although it is an annual plant, it will live over one winter if seeded in late summer or early fall. It is often seeded in corn or cotton when these crops are laid by. Crimson clover makes considerable winter growth, comes on very early in the spring, and is ready to be grazed off in time to seed cowpeas, soy beans, or peanuts. If allowed to produce its full growth, the season will be a little late for seeding corn or cotton. It will furnish grazing in early spring before Bermuda-grass pasture has made much growth.

Not all soils are suited to crimson clover. It does best on the Coastal Plain sandy loams. It is better adapted to the Middle

Atlantic States than it is to the soils and climate farther south, but it may often be used as a catch crop to good advantage in the latter region. This crop is of very little value when seeded in the spring, and it is doubtful whether it is profitable except when used as here indicated. Hogs relish crimson clover and do very well when pastured on it.

For further information in regard to this crop, see Farmers' Bulletin 550, entitled "Crimson Clover: Growing the Crop."

SOY BEANS.

There is perhaps no better crop for supplementary hog pastures throughout most of the cotton belt than soy beans. The crops which rival it most closely are peanuts and velvet beans. Soy beans have an objectionable effect on the color of the pork and the melting point of the lard, but not to such a marked degree as peanuts or chufas. The best varieties of velvet beans do not mature north of central Georgia and Alabama. Soy beans are not thus restricted. The gains made by hogs on soy beans are almost equal to those made on peanuts. The farmer is reasonably sure of getting a crop, and there are no serious drawbacks connected with their culture. They may be seeded after some winter-grown crop has been grazed off in the spring, thus making an economical use of the land. The soy bean is a soil-improving plant, and many farmers consider the increase in fertility to the soil where the crop is grown and grazed off equivalent to the cost of growing it. Hogs will eat the leaves and stems if turned on soy beans before they are mature. It is usually considered more profitable, however, to allow the beans to ripen before using them.

The reader is referred to Farmers' Bulletin 372, entitled "Soy Beans," for information in regard to the culture of this crop.

VELVET BEANS.

The velvet bean has grown steadily in popularity for the past 20 years as a forage crop for hogs. It is well suited to the light sandy soils of Florida and along the Gulf. By the introduction of sorts maturing earlier than the old Florida velvet bean, the culture of this crop has been extended much farther north than formerly. It is grown primarily for grazing in early winter and is not utilized until the pods are mature, which is usually in November or December. The pods do not shatter or decay easily, and the crop will furnish grazing for two or three months.

The chief value of this crop as a forage for hogs is in the grain, so its culture north of the limits where it matures seed is not to be recommended. Soy beans or cowpeas will give better results than velvet beans for the northern half of the Gulf States. As earlier maturing varieties are produced the region of their usefulness will be extended farther north. At the present time the Georgia velvet

bean, sometimes called "One Hundred Day" and "Speckled," will mature as far north as a line from Charleston, S. C., through Birmingham, Ala.

Some support is needed for the long, trailing vines of velvet beans, as the production of seed is lessened if the vines lie flat on the ground, and there is also more rotting of the pods. Corn is one of



FIG. 2.—A field of cowpeas before it was grazed by hogs.

the best plants to combine with this crop. It may be seeded in rows 6 or 7 feet apart, with a row of velvet beans between the rows of corn. It is advisable to let the corn have a start of two or three weeks before the beans are seeded. The yield of corn will not be large under these conditions, but the whole crop may be hogged off with excellent results. The pork produced by velvet beans is inferior in quality to that made from corn. Such pork should be cured locally into what is commonly spoken of as country-cured hams and bacon.

COWPEAS.

The cowpea crop needs little discussion. It has been grown in the South for a great many years. The ability of cowpeas to make a good growth on land low in fertility is well known. The crop is very useful for green manuring, for hay, and for hog pastures. It is best adapted to the sandy loam soils, where it makes a heavy growth. Hogs relish this crop and will eat the vegetative parts as well as the seed. One of the best ways to use cowpeas as a hog pasture is to combine some early variety with one of the early sweet sorghums for midsummer grazing. The cowpeas will stand late seeding and still produce a crop, and it is often used after oats or some

other winter crop has been harvested. The ripe peas also make good hog feed. These may be harvested, ground, and fed with corn meal as a grain ration to good advantage, provided the harvesting can be done economically. Where hand picking is necessary, it will be more profitable to graze the crop than to harvest it. (Figs. 2 and 3.)

For further information in regard to the culture of this crop, see Farmers' Bulletin 318, entitled "Cowpeas."



FIG. 3.—The field of cowpeas shown in figure 2 after being grazed by hogs.

PEANUTS.

Most of the southern agricultural experiment stations have experimented with peanuts for pork production. The opinions of the experimenters agree quite closely that it is one of the best forage crops for hogs when gains alone are considered. Pigs fed peanuts alone will make larger gains than when fed corn alone, but a combination of the two feeds will give better results than either alone. The hogs eat the seeds only. The tops may be made into hay for other stock and the hogs can finish the harvesting. The peanuts will keep well in the ground, so the grazing can be extended over quite a long period.

Unfortunately, peanuts do not produce lard and pork of good quality. The melting point of the lard is low, being from 10° to 15° below that of corn-fed hogs. The body lard will often melt at 75° F., or below ordinary room temperature in summer. This makes it very objectionable on the market. The pork is soft and has a dirty, yellowish cast instead of being firm and white like that made from grain. This latter fault is not serious to those who are acquainted with the superior flavor of peanut-fed pork. The hogs which produce

the famous Smithfield hams and bacon of eastern Virginia are finished in the peanut fields. The color does not matter in that case, because of the smoking which is given the meat in curing. Packing-house buyers discriminate heavily against peanut-fed hogs. This accounts in a large measure for the lower prices prevailing in the southern than in northern markets.

Several experiments have been conducted in finishing hogs for market in an attempt to overcome the ill effects of the peanuts. Corn fed for four or five weeks after the hogs have been taken off the peanuts will raise the melting point of the lard, but will not bring it up to the same degree as that of hogs which have not had peanuts. One of the best rations for this purpose tried at the Alabama Agricultural Experiment Station was composed of one part of cottonseed meal and three parts of corn. This ration was a safe feed for three weeks immediately before slaughtering, but no longer, on account of the poisonous effect of the cottonseed meal when fed to hogs. Most of the experimenters agree that grain fed to the hogs while they are running on the peanuts will do more to make firm pork than if fed during a short period after the hogs are taken off the peanuts. This crop will undoubtedly be used a great deal for hog production in the South, many farmers preferring to accept a lower price than to produce the pork without the use of peanuts. There seem to be splendid opportunities in the peanut-growing sections to develop a trade in country-cured hams and bacon similar to the Smithfield products of Virginia. This peanut-fed pork should then command a price higher instead of lower than that from corn-fed hogs.

Peanuts require a loose, open soil for best results, sand or sandy loams being especially suitable. Planting should not be started until the ground is well warmed, and it may extend over a period of two months. This will also extend the grazing period. The peanuts should be planted in 30-inch rows and kept well cultivated.

For further information in regard to the culture of this crop, see Farmers' Bulletin 431, entitled "The Peanut."

CHUFAS.

Many farmers in the South have grown chufas with satisfactory results, as far as gains in pork are concerned. Chufas belong to the sedge family of plants and are similar in appearance and character of growth to the well-known pest nut-grass. The rootstocks of chufas produce large numbers of small, roundish, tuberous growths. These tubers, often spoken of as nuts, are edible and have a sweet, nutty flavor. Hogs are very fond of them and will do their own harvesting. The quality of pork produced on chufas is not first-class, being soft and oily. Experiments have shown that chufa-fed pork and lard are no better than that made from peanuts. The sug-

gestions made under "Peanuts," in regard to the hardening of soft pork, are applicable to hogs fed on chufas.

Chufas grow best on light sandy or sandy loam soils. They will stand considerable dry weather when once established, which makes them valuable for much of the piny-woods lands near the Gulf. A peek of the tubers is sufficient to seed an acre. These should be soaked for several days and then planted in rows, so they may be cultivated. The planting time is from April to June. Sometimes they are planted between corn rows at the last cultivation. Chufas are ready to be grazed in about four months after planting, and they will remain in the ground without decaying over winter or until they are eaten. Some farmers use chufas as the first crop on newly cleared land. The rooting of the hogs in harvesting the tubers helps to destroy the native weeds.

SWEET POTATOES.

The value of sweet potatoes for hog forage is in dispute. The roots alone are scarcely a maintenance ration, but when combined with a liberal grain ration apparently give good returns. The large yields of sweet potatoes on sandy loam soils, together with their good keeping qualities, make this a crop that should receive consideration for hog feeding. It is ready for feeding, however, at the same time that many other desirable hog forages are mature, such as soy beans, velvet beans, or peanuts. The best use, perhaps, that can be made with hogs in handling the sweet-potato crop is to utilize the culls only or the main crop when prices do not justify selling the potatoes on the market. If grown especially for hog forage, one of the large-yielding stock varieties should be used.

Sweet potatoes are propagated chiefly by bedding the small or culled potatoes and transplanting the young shoots; late plantings are sometimes made with vine cuttings. The potatoes should be planted in hotbeds early in the spring. The shoots or slips are not transplanted until the ground is thoroughly warm. It takes from 2 to 5 bushels of potatoes to form sufficient slips to plant an acre, depending upon the size of the potatoes. A bushel of small potatoes will give more plants than a bushel of large ones. The plants are usually set in rows $3\frac{1}{2}$ feet apart and spaced about 18 inches apart in the rows.

For further information in regard to the culture of this crop, see Farmers' Bulletin 324, entitled "Sweet Potatoes."

MANGELS.

The Louisiana Agricultural Experiment Station has tested mangels as a forage crop for hogs with satisfactory results. The crop is best harvested and fed to the hogs in pens or while they are on other pastures. Mangels are suited to a fairly cool climate and will not

do well during the hot summer months in the South. If used there they should be seeded in early fall for winter use. This crop also demands a deep, mellow soil with plenty of moisture. It is not advisable to attempt to grow mangels on poor, hard, hilly land. The crop will make a large yield on rich alluvial bottom lands. Mangels should be planted in rows and kept free from weeds. When the plants are 2 or 3 inches high they should be thinned to stand 12 to 18 inches apart in the row. On account of the large amount of hand labor necessary to the successful culture of mangels it is doubtful whether this crop will ever come into general use as hog forage.

RAPE.

Rape as a forage crop for hogs has not been so popular in the South as in the North. It is a well-known plant of the cabbage family and is often grown in the South, under the name of smooth kale, as a garden vegetable for salad. It requires a cool, moist climate for best growth. In hot, dry weather it makes little growth and becomes tough and unpalatable to the hogs. This makes spring seedings, except the very earliest, unsatisfactory. The best use to make of rape for hog pastures in the South is probably for late fall and winter grazing. September seedings give good results, as rape stands light freezing without injury and will furnish grazing throughout the winter. It may be seeded broadcast or in drills. If drilled, it should be cultivated once or twice. It may be mixed with rye or oats in broadcast seedings. Three pounds of seed are sufficient for an acre when seeded in drills or in mixtures with grain, and 5 pounds are enough for broadcast seedings.

An acre of good rape should furnish grazing for three months for 12 to 15 hogs weighing from 75 to 100 pounds each.

SUGGESTED CROPPING SYSTEMS.

As previously stated, it is impossible to plan a succession of crops that will be satisfactory for any large number of farms. Each farmer must plan his own system according to his conditions of climate, fertility, and layout of fields. The following systems are merely suggestive and may be modified in a great many ways as occasion demands. As a rule the most simple cropping system will be the most satisfactory. No one of the systems suggested constitutes what might be termed a "complete succession of crops" except as it is used in conjunction with a permanent pasture. In case of a crop failure some substitute crop should be put in immediately. The success of a hog-pasturing enterprise depends on keeping the land occupied either with a growing crop or one that is being grazed. With the large number of forage crops described in this bulletin to pick from, covering in seeding dates the greater portion of the year,

there is no excuse for idle fields. As a rule it is not practicable to outline a definite rotation of crops with equal acreages. Corn, beans, or other finishing feeds are more essential than some of the other crops, and greater areas of these are needed because the pigs are larger when these are grazed.

On most farms it will be possible to seed some catch crop along with other farming operations, which will greatly help out the hog-pasturing enterprise. Rye and crimson clover may well follow cotton. Bur clover, once established on cotton land, will usually reseed itself. Oats and vetch may follow corn or sweet potatoes. All of these are valuable for hog forage. In most cases it will be more economical to plan a rotation for the whole farm containing several good forage crops, a portion of which may be fenced temporarily and grazed, than to devote a single portion of the farm to hog pastures exclusively. By this means the extra expense of working small areas may be avoided, and it will help to utilize the whole farm and also to save waste.

A FOUR-YEAR ROTATION FOR GENERAL FARMING.

By rotation of crops is meant a definite system of crops on fields of approximately equal areas. All of the crops are grown each year. The terms first year, second year, etc., refer to the order in which crops come on any one particular field. This is shown diagrammatically in the system recommended for fertile uplands (p. 20).

First year.—Cotton, with crimson clover, bur clover, or rye seeded when the cotton is laid by.

Second year.—Soy beans, sorghum, cowpeas, peanuts, or sweet potatoes, followed with some winter cereal seeded in the fall.

Third year.—Wheat, oats, oats and vetch, or rye, followed with cowpeas or soy beans.

Fourth year.—Corn, with a cover crop, such as crimson clover, seeded at the last cultivation.

Fifth year.—Cotton, etc. (Repeat rotation.)

This rotation would provide fall seed for finishing hogs, besides winter and early-spring pasture. A portion of the field devoted to the second-year crops may be seeded to any one or several of the crops suggested, thus providing midsummer pasture. If a farmer possesses a permanent pasture, no other forage would be necessary for the hogs than that supplied by this rotation.

HOG-PASTURING SYSTEM FOR FERTILE BOTTOM LANDS.

The system here suggested consists of a permanent pasture of 10 acres and three fields of 3 acres each. This should furnish sufficient feed to support 10 brood sows and their pigs.

First year.—Corn, in alternate rows with velvet beans, to be used for late fall and winter grazing.

Second year.—Sorghum and early cowpeas, to be grazed in midsummer and early fall and the land seeded to 2 acres of rape and 1 acre of mangels for fall and winter grazing.

Third year.—Soy beans or peanuts, grazed in the early fall and the land seeded to oats or rye and crimson clover for winter and spring grazing.

HOG PASTURING SYSTEM FOR FERTILE UPLANDS.

The system shown in the following diagram consists of 10 acres of permanent pasture and three fields of 3 acres each. It is planned for 10 brood sows and their pigs.

Ten acres, permanent Bermuda-grass-lespedeza pasture.	A.—THREE ACRES: <i>First year.</i>—Corn, with soy beans or velvet beans in alternate rows. <i>Second year.</i>—Sorghum and early cowpeas, seeded to oats or rye and crimson clover in the fall. <i>Third year.</i>—Oats or rye and crimson clover, followed by soy beans or peanuts.
	B.—THREE ACRES: <i>First year.</i>—Sorghum and early cowpeas seeded to oats or rye and crimson clover in the fall. <i>Second year.</i>—Oats or rye and crimson clover, followed by soy beans or peanuts. <i>Third year.</i>—Corn, with soy beans or velvet beans in alternate rows.
	C.—THREE ACRES: <i>First year.</i>—Oats or rye and crimson clover, followed by soy beans or peanuts. <i>Second year.</i>—Corn, with soy beans or velvet beans in alternate rows. <i>Third year.</i>—Sorghum and early cowpeas, seeded to oats or rye and crimson clover in the fall.

HOG-PASTURING SYSTEM FOR POOR CLAY UPLANDS.

The system here suggested is planned for 10 brood sows and their pigs, and should consist of 15 acres of permanent pasture and three fields of 5 acres each.

First year.—Corn and cowpeas, seeded early and followed by rye and crimson clover seeded after the corn is hogged off.

Second year.—Soy beans, to be grazed either at the same time as the corn or later.

Third year.—Sorghum and cowpeas mixed for midsummer grazing and the land to be put in oats for winter use.

HOG-PASTURING SYSTEM FOR LIGHT SANDY SOILS.

The system here suggested consists of 10 acres of permanent pasture and four fields of 3 acres each. It is planned for 10 brood sows and their pigs.

First year.—Corn in alternate rows with soy beans or velvet beans.

Second year.—Chufas or sweet potatoes.

Third year.—Peanuts or cowpeas, followed by rye and crimson clover.

Fourth year.—Winter oats and vetch.

BREEDS OF LIGHT HORSES

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FARMERS' BULLETIN 952
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief

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THIS BULLETIN gives concise information regarding the breeds of light horses and will be of particular usefulness to the farmer in those sections where light horses are preeminently fitted for his work, such as mountainous and hilly sections and where there are markets for horses for saddle and driving purposes.

The breeds discussed are the Arabian, Thoroughbred, Standardbred, American Saddle, Morgan, Hackney, French Coach, German Coach, and Cleveland Bay. Of these, the Standardbred, American Saddle, and Morgan breeds were developed in this country. The origin, development, general appearance, and adaptability of the light breeds are discussed.

There is no best breed of light horses. Some breeds are superior to others in certain respects and one breed may be better adapted than another to certain local conditions. The general requirements for a particular section and the popularity of a certain breed in a certain locality should receive the utmost consideration in choosing a breed.

BREEDS OF LIGHT HORSES.

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CHARACTERISTICS OF LIGHT HORSES.

THE TERM "light" when applied to horses refers to that class which is intermediate in size between ponies and draft horses and which usually has more range, a greater degree of quality, better action, or greater speed than either. A majority of our light horses are from 15 to 16 hands high and weigh from 900 to 1,250 pounds. Breeds of light horses, then, refer to the groups within this

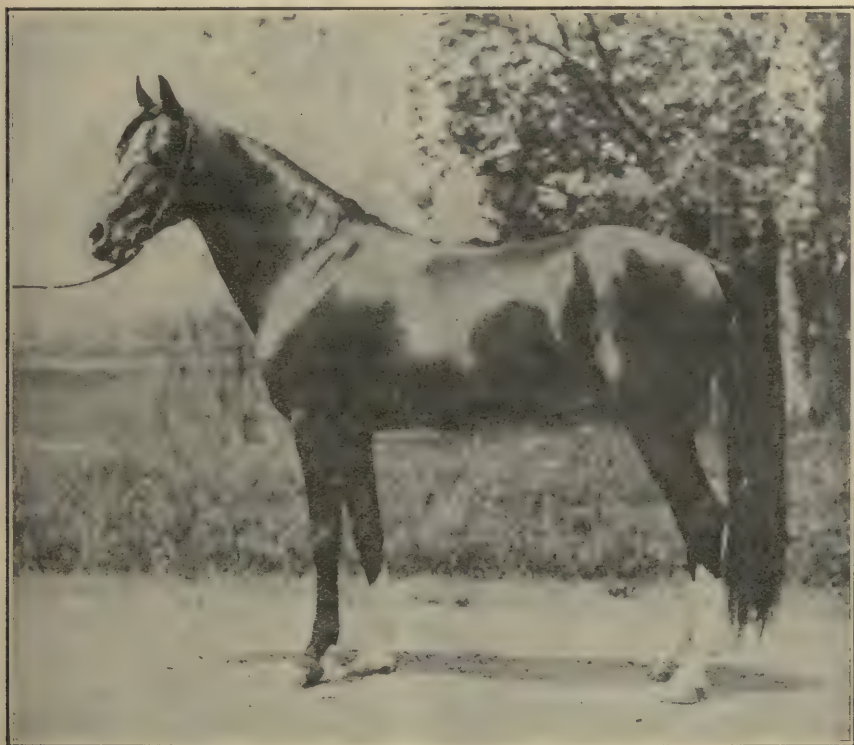


FIG. 1.—Arabian stallion.

class which have been bred pure for a particular purpose, individual ancestry having been recorded by a registry association.

Light horses are well adapted to mountainous sections and where the land is rolling, in which localities they are useful for farm horse power and for riding and driving purposes. It is in such sections that light horses should be bred and developed to supply the home demand.

The material presented herewith is intended to convey to the reader concise general information concerning the characteristics of the various breeds of light horses found in this country. An interesting study is afforded in noting the extent to which Arabian and Thoroughbred blood was used in founding many of the light breeds, and this relationship is briefly touched upon, but no attempt is made to give detailed information concerning early breed history. By communicating with the secretaries of the various breed associations, whose names are given, information regarding rules of registration, issuance of studbooks, and lists of breeders may be obtained. Farmers' Bulletin 619, "Breeds of Draft Horses," is available to those wishing information on the draft breeds.

ARABIAN.

The oldest breed of horses generally recognized at the present time and the fountainhead of all our other light breeds was developed in the desert country of Arabia, from which it derives its name. Needing an animal that could carry him swiftly and safely over long stretches of sandy soil and at the same time withstand the lack of food and water to a remarkable degree, the Arab developed a type of horse that has long been noted for its speed, endurance, docility, and handsome appearance.

The Arabian horse has been developed to perform his work practically altogether under saddle, and he possesses the general characteristics desired in a saddle horse—viz, good carriage of head and neck, deep, well-sloped shoulders, a short back with proportionately long underline, short, strong loin, tail attached high, compactness of middle, and superior quality of underpinning without any tendency to appear leggy.

Generally the Arabian horse in action shows only the walk, trot, and canter. The usual height is from 14 to 15.1 hands, and the weight varies from 900 pounds to 1,100 pounds. Bay, brown, and chestnut are the predominating colors, with occasional grays and blacks. While Arabian horses frequently have white marks on the head and legs, they seldom or never are spotted or piebald as is commonly supposed. This false impression evidently gained prominence because spotted circus horses are sometimes called Arabians.

Crossed on light farm mares, Arabian stallions have produced excellent saddle horses, but they frequently lack size when measured by our present-day market standards. However, admirers of the Arab are very enthusiastic about his suitability for cavalry use, claiming that his speed, even temperament, and especially his ability to withstand hardships such as scanty feed and extremes of heat, make him useful for this purpose.

The Arabian Horse Club of America, of which H. K. Bush-Brown, 1729 G Street, Washington, D. C., is secretary, has made considerable progress in bringing to the attention of our people the merits of the Arabian horse. The revised edition of the first volume of the Arabian Stud Book was published in 1908, and up to November 1, 1916, 86 stallions and 96 mares had been recorded.

THOROUGHBRED.

The name "Thoroughbred" is applied properly only to the breed of running race horses produced originally in England. Three Arabian stallions are credited with having laid the foundation for this breed, their names being Byerly Turk, The Darley Arabian, and Godolphin Arabian, and they produced the three famous racing families, Herod, Eclipse, and Matchem, respectively. The Thoroughbred has many

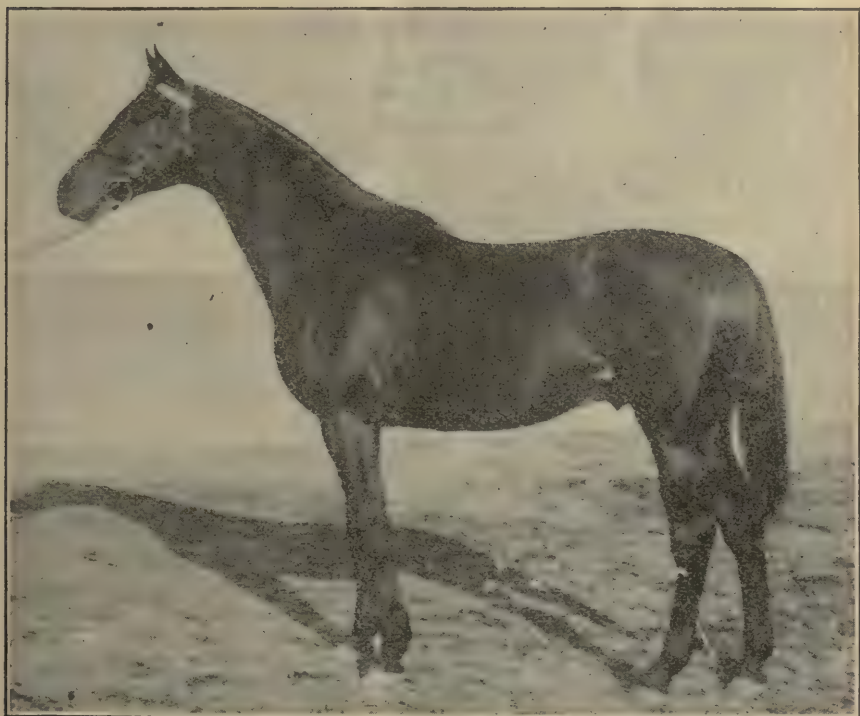


FIG. 2.—Thoroughbred stallion.

features of the Arabian, most notable of which is the general refinement or "breediness" of appearance. The cross on English mares, however, and the selection for running speed has resulted in the Thoroughbred being faster at the run, larger, and commonly more angular and upstanding than the Arabian. As a running race horse the Thoroughbred is without a peer. The canter is his best utility gait. Many specimens have a splendid walk, and the trot, while not showing extreme speed or knee action, is nevertheless often desirable for saddle use. Thoroughbreds are bay, brown, chestnut, black, and, less frequently, gray in color. Irregular and conspicuous white marks are not uncommon.

Thoroughbreds are bred pure almost entirely for racing purposes, a certificate of registration with the Jockey Club being required for horses entered in races on the larger tracks. To instill quality and a more active temperament, animals of this breed are sometimes used to cross into other breeds. The use of Thoroughbred sires on mares of other than pure Thoroughbred blood is quite popular in certain sections, the resultant animals being commonly termed half-breds. Such horses find ready sale as hunters, saddle horses, and polo ponies. Many excellent officers' horses and cavalry horses are produced in this way. When of proper temperament and of sufficient size they have also been very satisfactory for general farm work on rolling land, gaining for themselves a reputation for stamina and endurance.

The Jockey Club, of which W. H. Rowe, New York, N. Y., is registrar, registers Thoroughbreds in this country. To December 31, 1916, 35,960 stallions and 38,624 mares had been recorded. Most of our imported Thoroughbreds come from France and England, but horses of this breed are bred in several other European countries as well, showing that the breed enjoys a wide distribution.

STANDARD BRED.

The Standardbred is an American breed developed primarily for extreme speed at the trot and pace. The imported Thoroughbred stallions Messenger and Bellfounder founded this breed by leaving descendants that showed speed at the trot. The ancestry of the pacer is not different from that of the trotter, but to-day some families produce a much larger proportion of pacers than others, while many individuals show speed at both gaits. Both trotters and pacers are registered in the same studbook.

Horses of this breed do not show so much quality as the Thoroughbred, but usually have more substance, being heavier in proportion to their height. The ears, head, and bone particularly are coarser, and the hind legs are not quite so straight as in the Thoroughbred. In weight the Standardbred ranges from 900 to 1,300 pounds and



FIG. 3.—Standardbred stallion.

in height from 15 to 16 hands, but the best specimens are often around 15.2 and weigh about 1,100 pounds in good driving condition.

These horses are bred pure largely with the intention of producing extreme trotting or pacing speed for racing purposes. Individuals not inheriting speed have frequently been able to fill utility places on account of their size, wearing qualities, and good dispositions. This is equally true of those carrying half or more Standardbred blood, as they have been used in large numbers as general-purpose farm horses; they predominate as roadsters or driving horses and as light delivery-wagon horses. Occasionally excellent heavy-harness horses have been trotting bred; durable cavalry horses frequently carry this blood, and when of sufficient size this blood produces the best light-artillery horses to be found in this country in any considerable number and coming from a known source. On account of their versatility, horses of trotting-bred ancestry have been very popular here, and foreign countries have paid some very attractive prices for Standardbred breeding stock, especially stallions.

The American Trotting Register Association, of which Frank E. Best, 137 South Ashland Avenue, Chicago, Ill., is secretary, promotes the interests of the Standardbred and records pure-bred animals. To date 21 volumes of the studbook of this association have been issued, and over 63,000 stallions and 200,000 mares have been recorded.

AMERICAN SADDLE.

The early residents of Kentucky, Tennessee, Virginia, and West Virginia found horses with easy gaits to be the most desirable to ride over plantations, semimountainous grazing farms, and on long journeys. In the preference for such gaits they laid the foundation for and promoted the pioneer development of the American Saddle Horse. Sections of Missouri also soon took up the breeding of easy-gaited saddle horses, and to-day this State ranks next to the mother State (Kentucky) in the production of high-class individuals.

Thoroughbred, Morgan, and Canadian blood form the basis for this breed. The American Saddle Horse Breeders' Association recognized the following horses as foundation stock of the breed previous to April 10, 1908: Denmark, by Imported Hedgeford; John Dillard; Brinker's Drennon; Sam Booker; Tom Hal; Coleman's Eureka; Van Meter's Waxy; Cabell's Lexington; Copperbottom; Stump-the-Dealer; Texas; Prince Albert; Peter's Halcorn; Varnon's Roebuck; and Davy Crockett. At present Denmark alone is recognized as foundation stock.

The chief distinguishing characteristics of the American Saddle Horse are the easy gaits which are known as the rack, or singlefoot (a rather fast cultivated gait intermediate in movement between the trot and the pace), the fox trot, the running walk, and the slow pace, the last three being commonly referred to as the slow gaits, any one of them being accepted as the slow gait of a five-gaited saddle horse. The other gaits demanded in a horse of this type are the canter, the trot, and the walk. The demand for harness, combination, and walk-trot-canter saddle horses has caused many dealers and breeders to pay particular attention to the development of a balanced, fairly high, and swift trot.

Members of this breed are usually bay, brown, chestnut, or black, and most of them stand from 15 to 16 hands high and weigh from 1,000 to 1,200 pounds.

A great deal of interest has always been manifested by the breeders of Kentucky and Missouri in showing their horses and colts at county and State fairs, and this is undoubtedly responsible in a large measure for the constant selection in this breed for animals with a great deal of quality, unusual style (produced by a long, clean, crested, highly carried neck and "water-spout" tail), and fine disposition. Fine harness show horses frequently possess saddle blood. Those without the easy gaits but with quality and desirable saddle conformation are sold with short tails as three-gaited saddle horses for park and show purposes. Heavy-harness horses have occasionally come from this breed, while five-gaited saddle horses seldom come from any other blood. At the present time American saddle horses



FIG. 4.—American Saddle stallion.

are being bred pure in practically every State in the Union, and many are sold to Cuba, as well as to other countries.

The American Saddle Horse Breeders' Association, the organization recording pure-bred animals of this breed, reports 7,863 stallions and 13,521 mares registered to December 1, 1916. Six volumes of the studbook have been issued, and volume 7 is in the press. Robert H. Lillard, Louisville, Ky., is secretary of the association.

MORGAN.

The Morgans have sometimes been considered a family of the Standardbred, but as these horses have been bred more for their utility qualities than for speed, and as their characteristics are well established and perpetuated with marked regularity, it is proper to consider them as a distinct breed. The early development of the Morgans took place in the New England States, thus giving this country the credit of founding three light breeds. The foundation of the Morgan breed is attributed to a single stallion named Justin Morgan, a horse of remarkable prepotency. Little is definitely known concerning Justin Morgan's ancestry, but the late Joseph Battell's researches into his ancestry indicate that he carried considerable Thoroughbred blood.

Morgans are generally chestnut, brown, bay, or black in color, white marks not being common. Fifteen hands might be given as the average height, with the average weight around 1,000 pounds, but, as in all breeds, considerable variation may be found, 16 hands in height, with 1,200 pounds in weight, occasionally being obtained. This breed has always been noted for smooth lines, good style, easy keeping qualities, endurance, and docility, the latter not, however, being obtained at a sacrifice of ambition and courage. Small ears, good eyes, with great width between them, crested necks, well-sprung ribs, with the last one close to the point of the hip, deep barrels, fairly level croups, full quarters, and enduring legs and feet are the qualities that have made Morgan horses popular for nearly a century. They have good natural knee action, with considerable speed at the trot, some families having contributed materially to the up-building of the Standardbred. Others showing more saddle characteristics have exerted a marked influence on the American Saddle Horse. The demand for saddle horses continues to be normal, and Morgan breeders should keep this market in mind.

These horses were used almost exclusively as general-purpose farm horses in the New England States in the early days, as well as in other sections. To-day Morgans are distributed over the important farming sections of this country, and they have succeeded in mak-



FIG. 5.—Morgan stallion



FIG. 6.—Hackney stallion.

ing for themselves a reputation for hardiness, soundness, and usefulness.

Though the craze for trotting speed and the subsequent lack of demand for driving horses nearly resulted in the Morgan being temporarily forgotten, his friends have never lost faith in him and have never evaded an opportunity to exploit his good qualities. Recently Morgan breeding has become quite popular in some sections, the Morgan Horse Club being an outcome of this movement. This club is endeavoring to preserve the good qualities of the Morgans through united effort of its members, and its object is analogous to that of the Department of Agriculture in its work in the regeneration of the Morgan horse.

T. E. Boyce, Middlebury, Vt., is secretary of the American Morgan Register. Up to December 25, 1916, there had been recorded 6,932 stallions and 3,570 mares and geldings (about 50 of the latter). Three volumes of this book have been published.

HACKNEY.

The first driving horses used in England of which much is known were the Norfolk trotters, they being the result largely of breeding Norfolk mares to Thoroughbred stallions, thus giving the foundation for the Hackney breed.

This breed, judging from its best individuals, presents a striking illustration of the high degree to which the horse-breeding art may be carried, for many of them are wonderful specimens of horseflesh, combining extremely high all-round trotting action and fair speed with abundant substance and quality. For use in heavy harness the Hackney is without a peer, most of the show horses of this class at the present time belonging to this breed. Pure-bred and grade Hackneys also furnished many of the utility carriage horses when this type was in demand. Crossed with trotting-bred mares, Hackney stallions have sired many high-class carriage horses in this country. Most of the demand at present for heavy-harness horses is for show purposes, and to meet this Hackneys are usually bred pure.

Chestnut and brown are the most common colors found in the Hackney breed, although bays and blacks are seen. Regular white marks are rather common. In the show ring and also for distinctive carriage use, Hackneys are usually docked and have their manes pulled. In size the Hackney varies more than any other light breed. The small Hackney pony, 14.2 hands and under, and the 16-hand Hackney horse are both registered in the same studbook. Hackneys are heavy in proportion to their height when compared with other light breeds, their deep chests, well-sprung ribs, low flanks, and heavy croups and quarters all producing weight. The large Hackney sometimes is lacking in general quality, but this is not true of the best specimens, and certainly would not be a just criticism of those standing around 14.2 to 15 hands.

While, as previously stated, the Hackney possesses desirable heavy-harness action to a greater degree than any other breed, much of this action is developed by skilled training, biting, and shoeing.

Six volumes of the American Hackney Stud Book have been published, recording 1,893 stallions and 2,887 mares. The Hackney association in this country is known as the American Hackney Horse Society. Gurney C. Gue, 460 Fulton Avenue, Hempstead, Long Island, N. Y., is secretary.

FRENCH COACH.

The term French Coach is used in this country to designate horses produced in France largely by Government aid and with the special object of obtaining animals especially well suited for military purposes. Such horses are not known as French Coach in their native country, but are termed Demi-Sang (half-bred). In this country the term half-bred is applied to horses of half or more Thoroughbred blood, and as the French use the term in a similar sense an idea of the ancestry of this breed is furnished, it being the result largely of crossing Thoroughbred stallions on mares of desirable conformation, their breeding being of minor consideration.

This system of breeding often resulted in an animal of beautiful lines, with size, substance, style, and quality. In their selection of

breeding stock for producing this class of horses, the French have laid a great deal of emphasis on a strong, enduring trot.

While the French Coach horse is not so large on an average as the German Coach, many of the specimens stand around 15.3 to 16 hands and weigh 1,100 to 1,300 pounds, but fairly broad variations from these figures are to be noted. In color these horses are generally bay or brown, but chestnuts and blacks are seen. White marks are not common and are rarely extensive.

It is no wonder that these horses appealed to the American importer, with the result that the stallions especially were brought to this country in considerable numbers. As a harness horse, which was the field of equine activity assigned to the French Coach when he reached this country, he has been very commendable, and some of his get bred here have been successful in prominent shows. On account of their mixed ancestry, however, French Coach stallions do not always get the kind of colts that would be expected when crossed on our mares, and lately very few stallions of that breed have been imported into the United States, their pure breeding, however, still being carried on here to a limited extent.

The French Coach Horse Society of America keeps records of pure-bred horses of this breed in this country. Two volumes of the



FIG 7.—French Coach stallion.



FIG 8.—German Coach stallion.

French Coach Stud Book have been issued, and 2,384 stallions and 840 mares had been recorded to November 1, 1916. The secretary of the association is Duncan E. Willett, Maple Avenue and Harrison Street, Oak Park, Ill.

GERMAN COACH.

Germany, with the object of producing a large, strong, and active horse that would be especially well adapted to carrying the German soldier and his heavy equipment and to hauling artillery, established the breed of horses known in this country as the German Coach. In Germany there are several distinct breeds of such horses, each of which is registered in a separate studbook.

The German Coach horse is said to have an infusion of Thoroughbred blood, but the present-day types do not show much of it. He lacks quality and is the most phlegmatic of the light breeds, and is also the heaviest, often weighing over 1,400 pounds and standing over 16 hands high. But few specimens of this breed show a tendency to trappy action, and practically no attempt has been made to produce a fast trot. In color this breed is all that could be desired, most of the specimens being beautiful rich bays and browns, with some blacks. White marks are seldom conspicuous and often are absent altogether. As a general-purpose farm horse and as a heavy-harness horse, the German Coach at one time gained considerable popularity

in this country, but in general the stallions do not "nick" well with our mares.

The German, Hanoverian, and Oldenburg Coach Horse Association of America promotes the interests of this breed in this country and issues registration papers for German Coach horses of approved breeding. There have been recorded by this association 2,955 stallions and 588 mares, and two volumes of the studbook have been issued. J. Crouch, La Fayette, Ind., is secretary of the association.

CLEVELAND BAY.

Although little is definitely known concerning the foundation of the Cleveland Bay breed, it is generally conceded that Thoroughbred blood played an important part in giving the Cleveland Bay many of its desirable characteristics. The early development of horses of this type, which were selected for bay color with practically no white, took place largely on the pastured Cleveland hills of Yorkshire County, England, the color sought and the locality being responsible for the breed name. In England the Yorkshire Coach is considered a separate breed from the Cleveland Bay, but in this country they are registered in the same studbook.

Members of this breed are always bay in color. A small star and a few white hairs on the heels are permitted, but more conspicuous white marks are considered objectionable. The mane, tail, and legs are black. This is probably the tallest of the coach breeds, some specimens standing 16.3 hands high. The tendency to be upstanding



FIG 9.—Cleveland Bay stallion.

or leggy is apparent, and a lack of quality has been a common criticism. The Cleveland Bay has a powerful trotting stride, with fair road speed.

Horses of this breed were formerly seen in some of our larger shows, but probably, partly at least, on account of a lack here of favorable conditions for such a type they have not gained in popularity and are now seldom shown. In sections where hunters are raised, mares of this breed may be found desirable to breed to medium-sized Thoroughbred stallions, as they have in England.

The Cleveland Bay Society of America records and issues certificates of pure breeding for this breed. There have been recorded by this society 1,271 stallions and 544 mares. R. P. Stericker, 845 Sheridan Road, Chicago, Ill., is secretary.

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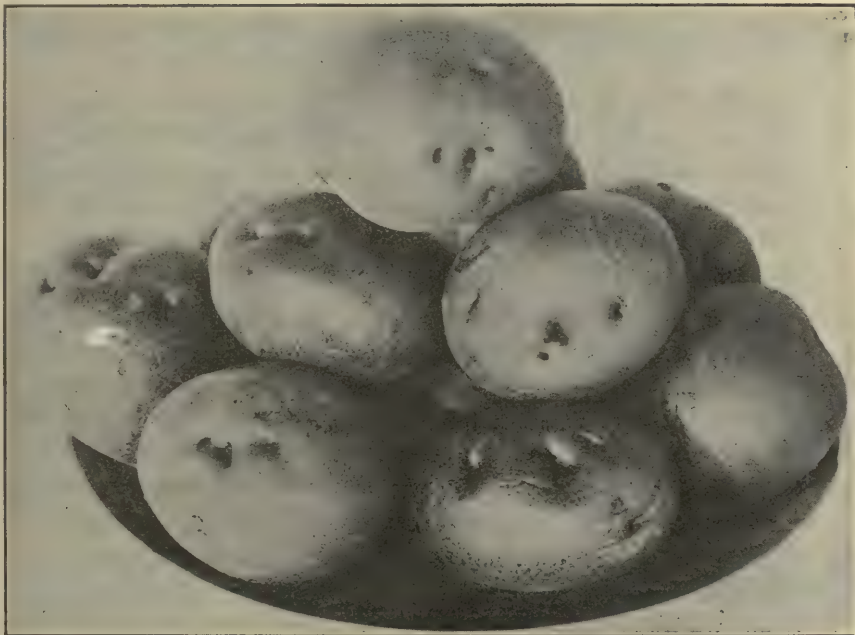
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POTATO CULTURE UNDER IRRIGATION

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and GEORGE W. DEWEY, Scientific Assistant

Office of Horticultural and Pomological Investigations



FARMERS' BULLETIN 953
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C.

June, 1918

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THE RAPID DEVELOPMENT of irrigation projects in the West and the well-recognized value of the potato both as a money crop and as a rotation crop have produced an ever-increasing demand for information as to the best cultural practices to adopt in the growing of potatoes under irrigation.

The information contained in this bulletin applies more specifically to the irrigated sections of Arizona, California, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming, in which more or less extensive acreages are devoted to the raising of potatoes.

Cultural and irrigation practices are not necessarily identical throughout the several States mentioned. A striking illustration of this is to be noted in connection with the tule, or peat, delta lands of the San Joaquin and Sacramento Rivers.

POTATO CULTURE UNDER IRRIGATION.

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EXTENT OF THE INDUSTRY.

WITH THE INCREASING settlement on irrigation projects in the West there has come a more and more insistent demand for information as to the best methods of growing potatoes under irrigation. This publication is intended to supersede Farmers' Bulletin 386, which is confined almost entirely to potato production in Colorado and is not sufficiently inclusive to meet the present requirements.

In the 12 States to which the information in this bulletin more specifically applies, Arizona, California, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming, the area devoted to the culture of potatoes under irrigation in 1909, as given in the Thirteenth United States Census Report, on page 863, was 166,417 acres. The data presented in Table I show the relative extent of the potato industry in each of these States and the percentage of the potato acreage under irrigation, which, as will be noted, is practically 50 per cent of the total area devoted to the crop. No accurate figures relative to new areas which have been brought under irrigation since 1909 are available, but such areas are undoubtedly large.

In considering the cultural and irrigation practices it has been the effort to make the information applicable to all the States mentioned. Because of the peculiar soil and irrigation conditions of certain sections of California it has been necessary to give cultural instructions for these sections different from those which apply to the rest of the irrigated districts.

TABLE I.—*Acreage and production of potatoes under irrigation in 1909 in the 12 States in the West considered in this bulletin.*

State.	Irrigated land planted to potatoes.		Production (bushels).	
	Area.	Ratio to total. ¹	Total.	Average per acre.
	<i>Acres.</i>	<i>Per cent.</i>		
Arizona.....	1,011	100	66,351	65.6
California.....	32,735	54.56	5,180,006	158.2
Colorado.....	59,221	91.10	8,408,915	142.0
Idaho.....	19,794	79.18	3,560,373	179.0
Montana.....	11,137	44.55	1,938,677	174.1
Nebraska.....	6,077	5.79	888,776	146.3
Nevada.....	4,711	100	728,227	154.6
New Mexico.....	1,119	100	83,234	74.4
Oregon.....	3,402	7.40	413,167	121.4
Utah.....	13,264	88.43	2,237,609	168.7
Washington.....	9,178	22.39	1,532,915	167.0
Wyoming.....	4,768	47.68	620,667	130.2
Total.....	166,417		25,658,917	
Average.....		50.00		154.2

¹ The percentage of the total area was computed by comparison with the data shown in the Yearbook of the United States Department of Agriculture for 1909, p. 491.

SUITABLE SOILS.

A sandy or gravelly loam soil is generally regarded as most suitable for the production of large yields of potatoes of good quality. Fairly good crops may, however, be produced on almost any type of soil except shifting sand or a heavy, sticky clay or adobe, provided the soil is well drained and possesses the required amount of plant food and moisture, coupled with sufficient organic matter to make it reasonably friable.

PREPARATION OF THE SOIL.

Broadly speaking, if the best results are to be obtained, the preparation of the land for a crop of potatoes should begin several years before the crop is actually grown. In order to bring the land up to its highest crop-producing capacity, this preparation should include a definite system of crop rotation combined with a judicious use of barnyard manure. In most of the irrigated sections of the West the rotation crop best adapted to this purpose is alfalfa. In a few localities red clover may be equally satisfactory, and it possesses the advantage over alfalfa of permitting a shorter crop rotation: but where it is possible to grow alfalfa successfully this crop should usually have the preference over clover. This is particularly true on land that is rather heavy or that is underlain with a more or less impervious subsoil, because of its deeper root penetration; however, on lighter soils provided with good subsoil drainage deep root penetration is not of such prime importance.

FALL OR SPRING PLOWING.

Where there is no danger from soil erosion during the winter, the land should be plowed in the fall, as the freezing and thawing during the winter disintegrate the exposed soil, putting it into a fine mechanical condition for the seed bed. The surface should be left loose and rough until spring, so that it will hold the snows and facilitate the penetration of rains.

Where alfalfa sod is to be turned under for a potato crop it is desirable to plow the land twice, in order to thoroughly destroy the alfalfa plants. The first plowing, which is technically known as crowning, should be made as shallow as possible—3 to 4 inches—while the last should be at least 8 inches in depth. When the period between the two plowings is comparatively short, the killing of the alfalfa crowns may be greatly facilitated by frequent disking or harrowing with a smoothing harrow the teeth of which are set rather straight. Disking or harrowing the freshly upturned crowns of alfalfa is an efficient method of destroying the plants, thereby avoiding much unnecessary work the following season in ridding the potato field of volunteer alfalfa plants.

When the plowing is deferred until spring the plow should be followed within a few hours by the harrow in order to pulverize the soil before clods are formed and the surface becomes dry and hard. Fall-plowed land should be disked and harrowed as early in the spring as may be necessary to conserve the soil moisture. If the preparation of the land has been completed some time before planting, the land should be harrowed at frequent intervals up to the date of planting in order to keep it in good mechanical condition and, what is still more important, to conserve the moisture that is stored up in the soil.

VARIETIES.

Experience has demonstrated that comparatively few varieties are adapted to any particular section. The grower should determine which variety or varieties do best on his farm and should confine his efforts to them. Usually it is not considered good practice to grow more than one early and one late variety unless there is some particular market requirement or a special reason for so doing. The Early Ohio is grown most extensively in Colorado for early consumption, while for the main crop the Pearl and Rural New Yorker No. 2 are grown almost exclusively in the Greeley district, whereas on the western slope of the Rockies the Russet Burbank and the Peachblow are the leading varieties.

In Idaho the Early Ohio and the Irish Cobbler are the leading early varieties, while the Russet Burbank (Netted Gem) and the Idaho Rural constitute the two leading late varieties.

In the Stockton district in California the Burbank is the leading potato.

SEED.

The importance of good seed can scarcely be overemphasized, as it is impossible to grow a maximum crop of potatoes if poor or even average seed stock is used. Good seed should be true to name and type and free from mixture and disease. (See the illustration on the title-page. This plate of potatoes consists of selected tubers weighing from $2\frac{1}{2}$ to 3 ounces each.) If scab or *Rhizoctonia* is present, or if the seed comes from a section where black-leg is prevalent, the tubers should be disinfected before planting.¹

WHOLE SEED COMPARED WITH CUT SEED.

The relative merits of whole and cut seed have long been in dispute and have served as the basis of considerable experimentation by many investigators. Where careful data have been taken on well-planned experiments it has been found that almost without exception the larger the seed piece used the larger was the total yield produced and the smaller the percentage of marketable tubers. Hence, the apparent advantage secured by an increased yield has generally been offset by the increased percentage of culls or undersized tubers, for which, with few exceptions, the American potato grower has no profitable outlet. In view of this fact it is the exception rather than the rule to find a grower who makes a practice of planting whole seed.

In the irrigated semiarid regions of the West, whole seed may be more advantageously used than in the humid potato-growing belt of the North and East, because it is possible with an abundance of irrigation water to increase the percentage of marketable potatoes over that which might normally be expected where the moisture conditions were solely dependent on the natural rainfall during the growing period of the crop. The employment of small, whole tubers from $1\frac{1}{2}$ to 3 ounces in weight insures a better stand and affords a greater degree of protection from the invasion of disease organisms than does the cut seed. Whether whole or cut seed is used, the seed piece, or set,² should be of sufficient size to furnish enough food to support the young plant until it can absorb its nourishment from the soil. Under adverse conditions, a small set often fails to accomplish this end.

¹ The treatment considered most efficient consists in immersing the tubers before cutting for $1\frac{1}{2}$ to 2 hours in a solution of one-fourth of a pound of corrosive sublimate to 30 gallons of water. Corrosive sublimate is only slowly soluble in cold water, but will dissolve readily in a small volume of hot water. It is extremely poisonous and should be kept away from live stock. Seed potatoes may also be disinfected by immersing the uncut tubers for the same period in a formaldehyde solution consisting of 1 pint of formalin to 30 gallons of water. This treatment is not as effective against *Rhizoctonia* as the corrosive-sublimate solution.

² The term "set" is here substituted for that of seed piece, partially on account of brevity, but more particularly because it is a well-accepted term in European countries.

CUTTING SEED.

The first step in cutting seed is to remove a thin slice from the stem end of the tuber, for the purpose of determining whether it is infected with *Fusarium* wilt or some other disease causing a brownish or blackish discoloration of the fibrovascular bundles or of the flesh. All tubers showing such discoloration should be discarded. In cutting seed potatoes it should be the aim of the workman to so divide the tuber as to give blocky sets each of which shall possess at least one strong eye. With medium-sized tubers this is best secured by first slicing the tuber in two lengthwise, making the cut



FIG. 1.—Typical 4-ounce seed tubers of the Irish Cobbler variety.

H20494HP

through the bud-eye cluster to the stem end, and then dividing each half in two crosswise. (See figs. 1 and 2.) Sets from $1\frac{1}{4}$ to $1\frac{3}{4}$ ounces in weight if cut as suggested will, if other conditions are favorable, give very satisfactory results. On the basis of a $1\frac{1}{2}$ -ounce set, with rows spaced 36 inches apart and the sets 12 inches apart in the row, it will require 1,361 pounds, or about $22\frac{3}{4}$ bushels to plant an acre of land. When it is remembered that the average weight of seed used to plant an acre of potatoes in the United States is less than one-half this amount, it is evident that this is one of the factors which is responsible for the low average production of potatoes in this country—less than 100 bushels—as compared with that of a number of the European countries—over 200 bushels per acre. Economy in the use of seed as a rule is poor policy for the grower to adopt.

CUTTING DEVICES.

Many cutting devices, some of which are automatic, have been developed for the purpose of lessening the labor cost of cutting seed potatoes. Automatic devices for cutting seed potatoes, whether operated by hand or by motive power, are not to be recommended if maximum returns from the crop are to be expected. The automatic cutter does not distinguish between a strong or a weak eye or no eye at all; hence it is quite possible to have, in certain varieties at least, a considerable percentage of eyeless or weak-eyed sets which give an imperfect stand of plants in the field, thereby appreciably



FIG. 2.—Tubers halved (on the right) and quartered (on the left).

lowering the yield. Automatic cutting machines may be used with a reasonable degree of satisfaction on varieties possessing numerous eyes well distributed over the surface of the tuber. The Early Ohio, Early Rose, and the Burbank are good examples of this class of tubers, while the Irish Cobbler, Rural New Yorker No. 2, and Pearl are good types of varieties on which automatic cutters can not be operated successfully.

A method of cutting which is considered an improvement over the ordinary hand-cutting method is that of fixing a knife in a stationary, upright position on a table, or platform, on which rests a hopper capable of holding one or more sacks of uncut tubers. Two baskets

or sacks are arranged at the edge of the table below the cutter. The knife is usually set with the edge of the blade away from the operator and directly in front of the hopper opening. The operator, after first removing a thin slice from the stem end, divides the tuber in two by clasping it with both hands and pulling it toward him. If the tuber is large enough to make four sets, the second operation divides the two halves horizontally. The sets are allowed to fall into one basket and the waste material into the other. Seated before such a cutting bench an operator can cut a very much larger quantity of seed and with greater ease than where the cutting knife is held in the hand.

CARE OF FRESHLY CUT SEED.

It is a good practice to dust freshly cut seed with flowers of sulphur, land plaster, or air-slaked lime. This can be done most conveniently with a flour sifter as the seed is being cut into the basket or sack. If the cut seed is not intended for immediate planting, it should be spread out in a rather thin layer in a cool place and turned over at least once in 24 hours for a few days in order to avoid any danger from its heating. After the cut surfaces are well healed over, the seed may be sacked up and held until wanted. The grower should be careful not to put disinfected seed into sacks or other receptacles which are infected.

PLANTING.

As a rule, planting should be done as early as conditions will justify, so that the crop will have time to mature fully before killing frosts. On the other hand, planting must be so timed as to avoid all unnecessary risks of having the young plants cut down by late spring frosts. In the potato districts of western Colorado, planting is begun about May 10, while in the Greeley district it is usually delayed until the first of June, in order to escape the early attacks of the flea beetle. In southern Idaho planting is usually done from May 10 to 30, while in the Stockton district of California potato planting may extend from March 10 to June 10, or even later.

In the production of potatoes on a commercial scale it is necessary to hasten the planting operations and reduce their cost by the use of machinery. There are two general types of planters in common use; namely, the so-called "picker," or 1-man planter, and the 2-man planter, of which there are at least two distinct types. In planters of the former type the seed pieces are picked up and dropped at regular intervals by means of spikelike projections called "pickers" attached to a vertical revolving disk. This type of planter has the advantage of dropping the seed automatically, thus requiring but one man, the driver, to operate it. On the other hand, if one of the pickers fails to secure a seed piece during its revolution, a missing

hill results. Furthermore, the pickers may be a source of infection, if disease organisms are present in the seed, as they may transfer the disease from infected to healthy tubers. The hole made in the seed piece by the picker may also furnish a means of entrance for disease organisms which may be present in the soil. With the 2-man type of planter the irregularities of feed are, or should be, adjusted by the extra man who sits on the rear of the machine and takes out or puts in extra seed pieces as occasion requires. With an efficient operator and a steady-moving team the dropping may be perfect.

The distance between the rows may vary from 30 to 42 inches, depending upon the variety, the locality in which the crop is grown, and the relative supply of plant food available in the soil. The usual distances, however, are from 36 to 38 or 40 inches. The distance between the plants in the row can be varied by adjusting the planter to drop close or far apart, according to the nature of the soil, the character of the preceding crop, and the variety to be grown. In some cases planting may be as close as 8 to 10 inches, while in others it may be from 16 to 18 inches. The more common distance is about 12 inches.

Depth of planting is very largely determined by the character of the soil. On light soils it is customary to plant the sets deeper than on heavy soil. Potatoes planted by machine should be placed at least 4 inches below the surface of the ridge, and on rather light soils a depth of 6 inches might be desirable in the irrigated regions.

In the reclaimed delta sections of the Sacramento and San Joaquin Rivers, in California, of which Stockton may be regarded as the center, rather interesting conditions are found. The soil of these reclaimed areas is generally spoken of as tule land. In this bulletin they are considered as peat lands, because for the most part they consist of decaying vegetable matter, varying from $1\frac{1}{2}$ to 20 or more feet in depth. Owing to the peaty character of these lands neither potato planters nor diggers have been successfully operated upon them. Planting in this region therefore is all done by hand. The customary practice is to plant the crop as the land is being plowed. The seed is dropped in the bottom of each alternate furrow and is covered by the next furrow, usually to a depth of 6 to 8 inches. The spacing of the rows varies with different plowmen, but usually ranges from 28 to 32 inches.

If the tule land is plowed in the fall or early winter it must be replowed in the spring in order to plant it.

Some of the better class of growers disk the land before plowing it for planting. It is considered a good practice to harrow or disk the land immediately after it is plowed, in order to conserve soil moisture by filling up the interstices between the furrows.

CULTIVATION.

Cultivation should be started as soon as possible after the potatoes are planted. The main objects to be accomplished by this early cultivation are (1) to loosen the ground, which has become more or less packed between the rows during the planting operations, in order to aerate and improve the physical condition of the soil; (2) to conserve soil moisture by improving its water-holding capacity; and (2) to kill the alfalfa plants that may have survived plowing, where crowning is not practiced, and also to kill all germinating weed seeds.

The type of cultivator most generally used is one that has four shovels about 4 inches wide, so constructed and adjusted that they will throw the soil toward, or even around, the plants. But with the possible exception of fields containing a large number of living volunteer alfalfa plants, it is believed that better results can be obtained by the use of a cultivator having eight narrow shovels, as there is less ridging, less fresh soil brought to the surface to lose its moisture, and the soil is more thoroughly pulverized, thus providing a better soil mulch to prevent the subsequent loss of moisture.

The cultivator should be followed by a smoothing harrow to pulverize the soil before it has had time to dry out and become hardened. The harrowing should be repeated at intervals of about a week until the potatoes are up. The later cultivations are preferably made with a harrow having its teeth set to slant backwards in order to avoid all unnecessary injury to the germinating shoots. After this, the cultivator should be used, but not set so deep as at the first cultivation. Cultivation should cease as soon as the roots of the plants extend far enough toward the center of the row to be seriously injured by the cultivator.

In irrigated peat soils, such as are found in the Stockton district in California, a light harrow serves every purpose for the early cultivations, or until the plants are well above ground. The subsequent care of the crop is much the same as that already described, except that no ridging of the soil is practiced.

IRRIGATION.

Irrigation practices vary considerably in different sections of the West and also in a given community. Different types of soil require different treatments. The customary practice in all irrigated sections of the West outside of the peat lands of the delta of the San Joaquin and Sacramento Rivers, or other sections having similar soil conditions is to run irrigation water through narrow and rather deep irrigating furrows between rows of potatoes. On the peat lands mentioned, water is applied to the crop by means of freshly cut, narrow

irrigation ditches from 24 to 30 inches in depth. These are usually cut between two rows of potatoes and are spaced from 60 to 75 feet apart. These distributing ditches are connected with feed, or supply, ditches, which may receive their supply of water through a head gate or a siphon direct from the river or from a large supply ditch or canal. A large portion of the land is below sea level, as well as below the river level, and when a tract of land has received the necessary quantity of moisture, the water level in the ditch is lowered by means of centrally located pumping stations which pump the water back into the river. The water is distributed through the soil from the lateral ditches by absorption. The peaty character of the soil absorbs and passes the moisture along like a sponge, so that in a relatively short space of time the moisture reaches the center of the 70-foot lands or cuts.

In Colorado, Idaho, and other Western States it is necessary before applying irrigation water to open furrows between each pair of rows or each alternate pair with a ditcher or a cultivator to which shovels are attached. These furrows should be comparatively deep and narrow, so that the water may be applied to the area below the tubers, in which the greater part of the root system is located. It is desirable to keep the irrigation water as low in the furrow as is necessary to prevent its direct contact with the area in which the tubers are developing.

There is considerable diversity of opinion regarding the proper time at which to make the first application of water, some growers contending that it should be withheld until the plants have set their tubers; others say that it is better not to apply water until the leaves of the plants show a decidedly dark blue-green color, which is considered a satisfactory indication of a lack of sufficient moisture; still others claim that the soil should not be irrigated until the foliage begins to wilt. In years of normal winter precipitation, if the land has been properly handled prior to planting the crop, there is sufficient moisture to carry the plants well along to the blooming stage. On the other hand, if winter rains and snows have been light and the ground does not possess sufficient moisture to insure good germination of the seed, it should receive an irrigation prior to the last fitting operation. If it should happen that unusual weather conditions should so sap the moisture from the soil after the crop is planted as to impair the vigor of the seed, the grower should not hesitate to apply water. This is usually called "irrigating up" the crop. Should the weather be very hot and the irrigation water warm, the grower runs some risk from decay of seed pieces by attempting to irrigate up. There is less danger from the application of water under such conditions if the land is irrigated at night.

The more general practice is to apply water whenever the crop appears to require it. If by careful conservation of the soil moisture through proper cultural methods the potato plants can be kept in a thrifty growing condition until the tubers are set, the withholding of water until after that period is probably to be commended. It does not seem possible that any good purpose can be served by delaying the application of water until the plants have begun to wilt.

After irrigation is once begun it should be continued at sufficiently frequent intervals to insure a continuous growth of the plants. If the checking of tuber development at any time during their period of



FIG. 3.—Heavy irrigation of potatoes during their growth. (Photograph from the Reclamation Service.)

growth is followed by a heavy irrigation, prongy or irregularly shaped tubers are almost certain to be produced, particularly with such varieties as the Early Rose, Early Ohio, and those of the Burbank type.

The uniformity of distribution of irrigation water is largely determined by the length of the run, the character of the soil, and the regularity of the irrigation furrow. The length of run is controlled to a large extent by the slope of the land and its character. If the field has but a slight fall or if the soil is loose and open, the run should be much shorter than is necessary when the percentage of grade is sufficient to insure a reasonably rapid movement of water and the soil is of a closer texture. A sufficient head should be turned into each ditch or furrow to carry the water to the lower end in the shortest possible time consistent with the avoidance of any undue washing of the soil. When the water reaches the lower end the head

should be cut down so that a small continuous stream will flow through each furrow. The rate of flow through the furrow may be more or less exactly governed by the use of irrigating tubes $1\frac{1}{2}$ inches in diameter and about 18 inches long connected with the supply ditch. The water in the supply ditch can be maintained at a given level by the use of board or canvas checks so arranged as effectively to arrest the flow of water in the ditch. The discharge of water through the irrigating tubes may be further controlled by raising or lowering the check boards or gates. For experimental purposes the irrigating tubes furnish a convenient and controllable means of applying a uniform supply of moisture to any given set of plants on which the duty of water is being studied. The practical grower does not, as a rule, use the irrigating tubes, because it is more convenient to turn a heavier stream of water into the irrigating furrows and use his judgment in regulating the flow. (See fig. 3.)

CROP ROTATION.

The crop rotation that is generally practiced on the irrigated farms of the West on which potatoes are grown consists of alfalfa from three to five or more years, followed by two crops of potatoes, after which a crop of grain is grown, generally oats, barley, or wheat, in which alfalfa is sown. In other words, with land in alfalfa five years, two crops of potatoes are grown every eight years, while with land three years in alfalfa, two crops are produced every six years. At two stations now being operated by the United States Department of Agriculture a 4-year rotation is being followed, namely, two years in alfalfa and one each in potatoes and grain. Whether or not it is desirable to take two successive crops of potatoes from the same land is largely dependent on the extent to which the soil is infected with potato parasites. It has been observed that a much larger percentage of diseased plants occurs on land previously devoted to potatoes, and the percentage is still further increased with a third crop. As has been previously suggested, where clovers can be successfully grown and a shorter rotation is desired clover may be substituted for alfalfa in the rotation scheme.

POTATO PESTS.

As a rule, potato pests controllable by spraying are not serious menaces to the crop on the irrigated farms of the West.

INSECT AND EELWORM PARASITES.

The most serious parasites are flea-beetles, the tuber moth, and the nematode. Flea-beetles are partially held in check by thoroughly spraying the plants with a combination arsenical-fungicidal spray consisting of 3 pounds of arsenate of lead to 50 gallons of Bordeaux mixture made from 5 pounds of copper sulphate and 5 pounds of

lime. Flea-beetles are not easily poisoned and are only indifferently repelled by the distastefulness of foliage covered with Bordeaux mixture.

Neither the tuber moth nor the nematode is controlled by arsenical or contact insecticides. The only way in which they can be combated with any degree of success is by systematic crop rotation and the planting of noninfected seed stock; in other words, preventive rather than remedial measures should be employed. Graf,¹ in a recent publication, says:

The numbers of the insect [tuber moth] should be reduced by practicing good farming and leaving no tubers exposed for the insect to work on. . . . Once the tubers become infested the best way of ending the damage is to fumigate with carbon bisulphid, using 2 pounds to 1,000 cubic feet of air space (measured before storing the tubers) and allowing 48 hours for fumigation.

Fortunately, the tuber moth is not a serious pest outside of certain areas in California, and the nematode is also largely confined to the tuber-moth areas in California and in portions of Nevada. The damage caused by either of these pests is, in the aggregate, relatively insignificant.

FUNGOUS DISEASES.

The principal fungous diseases are those which live over in the soil, such as the Fusarium wilt, Rhizoctonia, and potato scab. The first of these can be successfully held in check only through the rigid rejection of all infected seed tubers when cutting the seed, the removal of infected plants from the seed plat, and by crop rotation. Tubers showing Rhizoctonia sclerotia may be disinfected by immersing the uncut tubers in a corrosive-sublimate solution for 1½ to 2 hours, but as most soils, particularly those which have been in alfalfa, are more or less abundantly infected with Rhizoctonia, the seed treatment may not materially lessen the infection.

Seed tubers infected with scab may be thoroughly disinfected by the corrosive sublimate or the formalin treatment, but here, again, unless they are planted on scab-free land, the treatment may be of little avail.

Early blight may sometimes cause serious loss, but its prevalence is not widespread nor constant in the region now under consideration, and for that reason control measures are not advised.

The late blight, so far as known, does not occur in the irrigated regions of the West.

On the whole, control measures are largely of a sanitary nature, and if due attention be given to crop rotation and to the planting of disease-free seed, little apprehension need be felt regarding undue losses from these sources.

¹ Graf, J. E. The potato tuber moth. U. S. Dept. Agr. Bul. 427, p. 51. 1917.

SEED SELECTION AND THE SEED PLAT.

HILL SELECTION.

If the best results are to be attained in potato production, greater care must be given to the development of high-grade seed potatoes than is the present practice.



FIG. 4.—Yield of tubers from a run-out Russet Burbank plant.

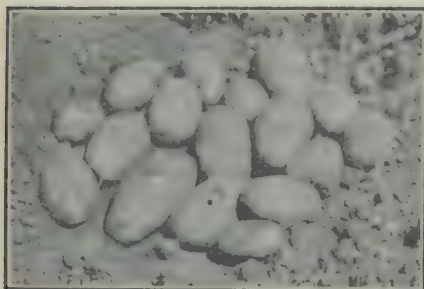


FIG. 5.—The progeny of a normal Russet Burbank plant, showing uniformity of shape and size.

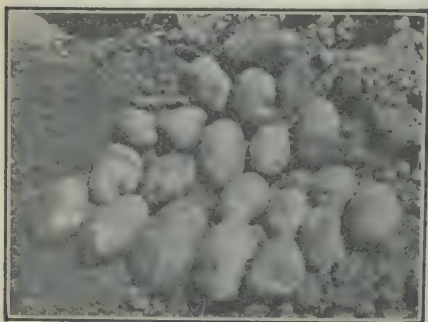


FIG. 6.—Yield from a normal Russet Burbank plant but with a more numerous progeny than that shown in figure 5.

Wherever the climatic and soil conditions are such as to make it possible to produce a good quality of seed potatoes, each grower should have his own seed plat. In the selection of seed potatoes it should be borne in mind that the hill rather than the individual tuber is the unit. The method which is most certain to lead to improvement is that of hill selection.

There are various ways of procedure in the practice of hill selection, but the one most likely to give the best results is that of marking the best plants in the field or the seed plat before the foliage begins to ripen and digging them by hand just before harvesting the main crop. The product of each individual plant should be examined separately, and only those that show uniformity in size and shape and that have produced a maximum number of merchantable tubers should be selected. (See figs. 4 to 6.) Each selected hill should be given a number, sacked separately, and a careful record made. The following season the tubers of each selection should be planted separately in order that their behavior may be noted throughout the growing season. It will be found that many of them possess no superiority over the



FIG. 7.—A good type specimen of the Early Ohio potato.

H20269HP

general run of field stock, but a few will be decidedly good. A large number of these progeny can be marked for discard before they are harvested. At harvesting time the progeny of each promising selection should again be studied carefully and only those which seem to possess superior merits retained. If it is possible to reduce these to one or two, it is desirable to do so. Further progress along this line consists in increasing the progeny of



FIG. 8.—Good specimens of the Russet Burbank potato.

H18320HP

the selection or selections as rapidly as possible. At the end of the third season a sufficient quantity should be available to plant the field crop. It is desirable to maintain a seed plat each year and to

continue the process of hill selection and the development of pure strains. In order to practice potato selection intelligently it is necessary to have a true conception of the type of the variety or varieties being used. For the guidance of those who are not thoroughly familiar with varieties, type specimens of some of the leading ones are shown in figures 7 to 12.

IMMATURE SEED.

Relatively few growers in the United States really maintain a seed plat, and still fewer practice planting the seed plat at a considerably later date than the main crop in order to secure

small to medium sized immature tubers, as is the custom with many English and Scotch seedsmen. In planting the seed plat designed for the production of seed for the main crop the following season, it is desirable to plant 2 to 3 ounce whole tubers. (See illustration on the title-page.) The use of whole tubers insures a perfect stand and a minimum percentage of diseased plants. At the same time, as a result of late planting and the heavy set produced by whole seed, the tubers do not attain a large size and are thus ideal for seed purposes. The date of planting the seed plat should be governed by the locality in which the potatoes are to be grown. In general, it might be said that the seed plat should be planted as late as it is possible to insure a good tuber development before the plants are killed by the frost in the autumn.



H20272HP

FIG. 9.—A good specimen of the Rural New Yorker No. 2 potato.



H14238HP

FIG. 10.—A good specimen of the Pearl potato.

HARVESTING.

Where an early crop is grown, the date of harvesting is largely governed by market conditions. If the price is high, a crop may often be harvested profitably when it is half or two-thirds grown, whereas if prices are low it is generally advisable to allow the tubers to reach full development before they are dug. In the case of late varieties destined for winter consumption it is the usual practice to delay harvesting as long as it is safe to do so without running unnecessary risk of freezing the tubers.

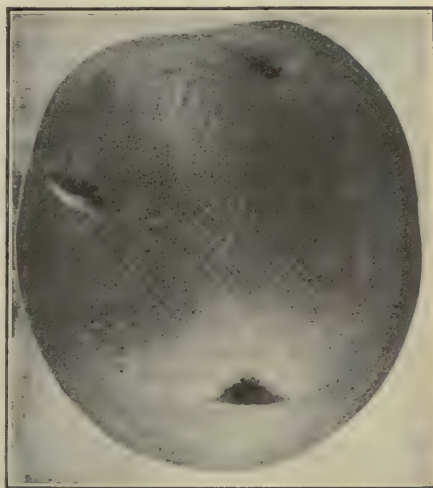


H20273HP

FIG. 11.—A good specimen of the Perfect Peachblow potato.

they are picked up. The sorting or grading of potatoes in the field is most economically done by using a potato grader of the shaker or belt type. These graders are mounted upon a wooden sled and are hauled along by a horse, as shown in figure 14. The sorter has two screens, arranged one above the other. The diameter of the openings in the upper screen in some graders is $1\frac{7}{8}$ inches and in others 2 inches, while the lower one may have openings anywhere from $\frac{1}{2}$ to $1\frac{1}{4}$ inches in diameter. Some makes of graders or sizers have wire-mesh screens with square openings, while others have circular or oblong openings with circular ends. Three pickers usually work with one sorter, each taking a row. The potatoes are picked into wire or splint baskets having a bail handle, and as the baskets are filled they are dumped on the upper part of the top screen and then shaken down. The

With few exceptions, the potato crop is harvested with an elevator digger drawn by four horses. (See fig. 13.) When the crop is sold from the field, it is a common practice to sort and sack the potatoes as



H18325HP

FIG. 12.—A good specimen of the Idaho Rural potato.



H830HP

FIG. 13.—Harvesting potatoes in Colorado with a digger drawn by four horses.

large potatoes passing over the top screen are diverted into one sack and those passing through the upper screen and over the lower go into another sack. One man drives the horse and operates the sorter while another sews the sacks and assists in loading the wagons. One digger with the necessary crew of men and teams can harvest from 3 to 4 acres a day.

On the peat lands in the Stockton district in California the potato crop is harvested by hand, the potatoes being picked up by the digger as soon as uncovered.

STORAGE.

The question of storage has, with few exceptions, received greater consideration by potato growers of the West than by those of the East. Nearly every farm is provided with a more or less suitable and serviceable potato storage cellar of a type which is quite distinctive to the West. (See figs. 15 and 16.)

Each year the grower must decide for himself as to the wisdom of storing his crop for winter disposal. Generally it pays to do so, because prices, as a rule, are rather low during the autumn



H2460HP

FIG. 14.—Sorting potatoes in the field as gathered. The potato sorter is mounted on a rough wooden sled hauled by one horse.

months; then, too, the crop can be handled much more quickly when it is stored on the farm as dug than if the grower is obliged to haul it to the shipping station.

It is estimated that on the average about two-thirds of the Colorado potato crop is put into storage.

The potato storage cellars, or "dugouts," as they are frequently called, are usually constructed so that they are partly below the ground level. The walls may be of earth, rough lumber, or concrete. A cheap but substantial storage cellar may be constructed by choosing a knoll and making an excavation from 2 to 4 feet in depth, then setting posts about 6 feet apart along the sides and ends of the



H19512MP

FIG. 15.—A very satisfactory potato storage house. In this particular house advantage has been taken of a narrow ridge. By cutting through it, a ground-level entrance was possible from both ends of the house. Note the earthen side walls.

earthen walls at a sufficient depth to insure their stability and of a length to provide the necessary headroom within the storage cellar. A 2 by 8 or a 2 by 10 plank is spiked to the upper end of the posts for the support of the rafters. The roof pitch may vary from a 16° to a 32° angle.

The rafters may consist of rough poles spaced 12 to 16 inches apart and of sufficient strength to support the roof and its covering of straw and earth. (See fig. 16.) Ample provision for ventilation should be made before the roof is covered. Usually one line of ventilators along the ridge or at one side of it about 10 feet apart and 12 by 12 or 12 by 16 inches in size, provided with caps to exclude rains and snows and further supplied with dampers which may

be closed or opened as desired during cold or moderate weather, furnish ample ventilation. The rafters, as well as the exposed portions of the side and end walls, are covered with heavy woven-wire fence netting, and on this a heavy layer of straw should be spread, which in turn is covered with 6 to 12 inches of soil on the roof and a correspondingly greater thickness on the sides and ends. Entrance to the storage house is usually provided for by a central driveway, the driveway entrance being protected against cold by two sets of doors arranged with a vestibule between, or, where a ground-level entrance is not possible, by a bulkhead entrance.

The interior arrangement usually consists of a series of bins on either side of the driveway.



H1607HP

FIG. 16.—A storage house in process of construction. Note the method used of placing ventilators in the roof.

Successful storage of the potato crop with a minimum amount of shrinkage is dependent to a large extent upon the following factors: (1) The exclusion of all badly cut or unsound tubers, (2) storing the tubers in well-ventilated bins and at a depth (5 to 6 feet) not too great, and (3) careful attention to the regulation of temperature and ventilation and to the exclusion of light. If the storage cellar can be kept at a temperature of 36° to 38° F., it will be sufficient to keep the tubers in a good state of preservation. Under good storage conditions the loss from the evaporation of moisture and from decay should not greatly exceed 5 per cent. The average loss is from 10 to 20 per cent. For further information on storage and storage-house construction, see Farmers' Bulletin 847, entitled "Potato Storage and Storage Houses."

MARKETING.

No fixed rule can be laid down regarding the time when the crop can be marketed to the best advantage. As market conditions are so variable from year to year, prices can not be predicted with any degree of certainty except in seasons when there is a decided shortage in a territory which enters into market competition with another given area. Under such conditions one can be reasonably certain of good prices at some time during the normal marketing period.

Potatoes should be carefully graded before marketing, and all diseased, sunburned, ill-shaped, or badly cut tubers should be removed. In some instances, where cooperative marketing is possible, it may be feasible as well as profitable to go even farther than this by making two or more grades, according to the size of the tubers. If the crop is marketed in sacks, they should be clean, bright, and well filled. Loosely filled sacks present an unattractive appearance, and at the same time the tubers suffer greater mechanical injury through handling.

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THE DISINFECTION OF STABLES

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FARMERS' BULLETIN 954

UNITED STATES DEPARTMENT OF AGRICULTURE

Revised May 40

Contribution from the Bureau of Animal Industry

JOHN R. MOHLER, Chief

Washington, D. C.

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THE WORK of the Bureau of Animal Industry in dealing with infectious diseases of live stock has shown that the average stockman and farmer does not sufficiently realize the importance of thoroughly disinfecting his premises following an outbreak of contagious disease.

Invisible organisms—germs—of various kinds have been identified by the microscope as the direct cause of many diseases of animals. Unless destroyed these germs have the power to maintain themselves on premises for indefinite periods. So long as they thus remain they are a constant menace and may at any time be the cause of an outbreak.

Proper disinfection destroys disease germs. There is, however, much lack of information concerning the destructive powers of the various disinfectants, and of the best and most economical ways of using them.

Thoroughness in doing the work is most important. Careless disinfection is little better than none at all, because it does not insure against future trouble.

This bulletin describes some of the more reliable disinfecting agents, together with approved methods of their application.

THE DISINFECTION OF STABLES.

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THE NECESSITY FOR DISINFECTION.

IT IS but natural to acknowledge the presence of only such objects as can be seen with the unaided eye. Science, however, by means of the high-power microscope, has clearly proved the existence of numerous minute animal and vegetable organisms—microorganisms—and it is a matter of common knowledge that many of these organisms frequently find their way into the animal body and produce disease. It is also well known that these microorganisms, or germs, vary in form and other characteristics and that for each disease of an infectious nature there is a specific germ.

If these germs could be confined to the animal body and die with it there would be no such things as an infectious disease. Unfortunately, however, they are thrown off by the animal through the excretions and lie in the soil, in the litter of stables, upon the floor and walls, and in cracks and crevices. Here they may remain and maintain their virulence for an indefinite period, ready at any time to be gathered up by an animal in its feed or to be blown about in dust and drawn into the lungs.

For example, we have tuberculosis in cattle and glanders in the horse. In the former disease the causative agent is a rod-shaped germ (*Bacillus tuberculosis*) which averages about one ten-thousandth of an inch in length. Cattle affected with tuberculosis pass myriads of these germs with the manure, and it is not difficult to understand how in the average stable they would have little difficulty in finding many lodging places.

In glanders the causative agent is another rod-shaped germ (*Bacillus mallei*), about the same length as the tuberculosis germ,

but somewhat thicker. A characteristic of this disease is the formation of ulcers in the nostrils and other portions of the body, from which there is more or less discharge laden with the glanders germ. And here, again, it is not difficult to understand how one diseased animal may contaminate extensive premises.

As has been stated, some of these minute forms are vegetable organisms. In fact, these vegetable parasites are the cause of some of the most destructive diseases, and some of them are very difficult to destroy, for the reason that they contain spores. A spore may be likened to the seed of a plant, for it bears about the same relation to the bacillus that a grain of wheat does to the plant proper. As

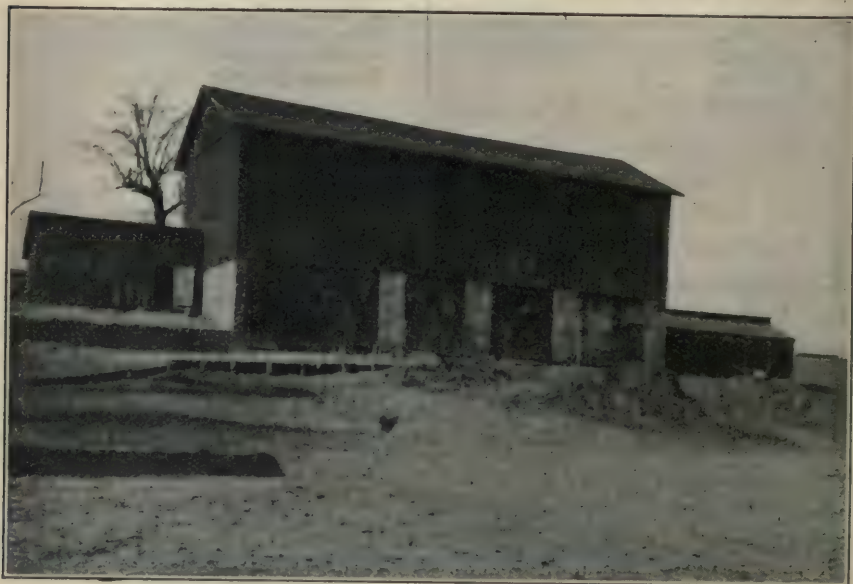


FIG. 1.—A stable with insufficient light and ventilation. Such a building is a favorable place for the existence of disease germs.

the plant may be destroyed and the seed remain latent for an indefinite time, so destruction of the bacillus may be accomplished while the spores remain unharmed and retain life for weeks, months, or years.

An example of this class of organisms is seen in the agent which causes anthrax (*Bacillus anthracis*). Ordinary methods for the destruction of the bacillus will not destroy the spore as well, and thus anthrax becomes a most difficult disease to eradicate. Upon farms where animals have died from anthrax and the carcasses have been buried instead of destroyed, repeated outbreaks of the disease may occur from time to time, possibly extending over a period of several years. This condition is due to the existence of the very resistant spores, which under favorable circumstances are carried to the sur-

face of the earth and become infecting organisms—much as the seed of a noxious weed, after remaining in the soil during the winter, finds the conditions favorable in the spring and develops into a plant—except that these minute forms of life multiply with the most wonderful rapidity.

Thus it is that our increased knowledge regarding microorganisms or bacteria as the cause of many animal diseases has emphasized the importance of disinfection.

THE NATURE OF DISINFECTION.

The work of disinfection is based upon our recognition of the presence of disease germs, and disinfection means the act of destroying the cause of the infection. In other words, disinfection is a removal of the cause, and it will be clear to any practical man that in dealing with disease any effort which stops short of a complete removal of the cause is most unwise and unprofitable. To those unaccustomed to the work, disinfection may seem a most complicated process. Any approved method, however, is comparatively simple when carried out carefully, although like many another procedure it is one in which attention to details counts for much. It is important to bear in mind that the causative agents of many diseases are extremely small and may remain for an indefinite time in dust, cracks, and crevices of buildings, so that efforts aiming at the eradication of disease from contaminated premises must be thorough in order to be effective.

DISINFECTANTS.

In the work of disinfection nature has provided man with a most valuable ally—sunlight. It is well known that the direct rays of the sun are inimical to many forms of bacteria, in some cases destroying them and in others lessening their influence. Thus the importance of well-lighted stables is evident. The dark and sunless building will be a favorable breeding place for bacteria, and the structure which admits the greatest amount of sunlight will be the least favorable for their development. Again, heat will destroy the bacteria of disease. By this is not meant the ordinary heat of the sun, but heat as developed in boiling water or in flame. It is upon this principle that the surgeon before operating renders his instruments free from the possible presence of bacteria by boiling, and it is the heat therein which renders a jet of live steam destructive to bacteria. Sunlight, however, can not be considered more than an accessory in the destruction of bacteria, while the application of heat in the form of steam is seldom possible and the use of a flame torch is not a safe procedure in the average building. Consequently, in the

practical work of disinfection we are depending upon certain drugs, which have power to destroy the organisms of disease.

Such drugs are known as disinfectants, and, fortunately, we have at hand a number that possess the power of destroying bacteria. It is not the purpose here to consider further the relative values of these drugs, neither will it be necessary to discuss the exact manner in which they act. It is sufficient to know that they possess the power of destroying bacterial life with the same certainty that poisonous drugs destroy animal life. They have only to be brought in contact

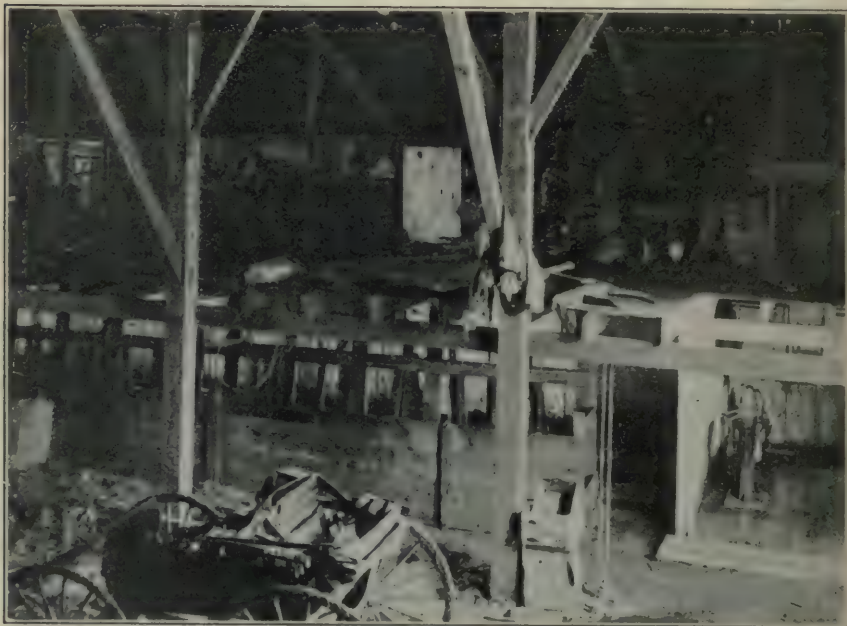


FIG. 2.—A stable that is difficult and expensive to keep clean and free from the contamination of animal diseases. Before beginning the disinfection of this stable a thorough cleaning would be essential.

with the bacteria in order to destroy them. As disinfecting drugs vary more or less in potency and in adaptability to general use, possessing certain advantages as well as disadvantages, it may be well to describe briefly a few of the commoner forms.¹

BICHLORID OF MERCURY.

Bichlorid of mercury, known also as corrosive sublimate and mercuric chlorid, is used in solution in water, commonly in a strength of 1 to 1,000, though solutions of double that strength may be employed.

¹ For fuller details regarding disinfecting agents the reader is referred to Farmers' Bulletin 926, "Some Common Disinfectants," by Dr. M. Dorset, chief of the Biochemic Division, Bureau of Animal Industry, from which some of the information herein given has been derived.

Although possessing great germicidal power, it has the disadvantages of being a violent poison, of corroding metals, and of uniting with albuminous substances, such as excreta, blood, etc., and thus forming inert compounds. Unlike the coal-tar products, it leaves no odor in the stable, which is an advantage in connection with the production of milk. On the other hand, care must be used in the handling of a solution of this drug, and feed boxes to which it has been applied should be washed with clear water before animals are again permitted access to them.

CHLORID OF LIME.

Chlorid of lime (chlorinated lime) is a well-known disinfectant, although its value is doubtless greatly overrated. This may be due in part to the fact that it is a powerful deodorant—such drugs on account of their pungent odor being popularly believed to have great disinfecting power. Being of uncertain strength and somewhat destructive to metals, and having a permeating odor especially objectionable in a stable where milk is produced, chlorid of lime can not be classed as the most desirable of disinfectants. For general disinfecting purposes it may be mixed with water in the proportion of 6 ounces to the gallon.

FORMALDEHYDE.

An aqueous solution containing approximately 40 per cent of formaldehyde and known as formalin has of recent years become a more or less popular disinfectant.

Formaldehyde is used in either liquid or gaseous form. In the former case formalin is mixed with water in the proportion of 6 ounces to the gallon, and the resulting solution is applied directly to surfaces or substances which are to be disinfected.

Formaldehyde gas is in most cases impracticable for stable disinfection. Where, however, a stable can be made almost air tight, and the animals removed, it will be found very serviceable, as it penetrates every crevice.

Several methods are in vogue for disinfecting with formaldehyde gas. Probably one of the most simple and practicable is to liberate the gas by means of the chemical reaction which takes place when formalin is poured upon permanganate of potassium. For each 1,000 cubic feet of air space $16\frac{2}{3}$ ounces of crystallized or powdered permanganate of potassium is placed in a wide-surfaced pan; 20 ounces of formalin is then poured upon it, and the room immediately closed for a period of 12 hours or longer. This method is efficient only when it is possible to seal tightly the rooms or compartments to be disinfected and when their temperature is not below 50° F.

CARBOLIC ACID.

Carbolic acid in its pure form is, at ordinary temperatures, in the shape of long, white crystals. For convenience it is frequently dispensed in liquid form by the addition of 10 per cent of water. A 5 per cent solution of carbolic acid is sometimes used as a disinfectant, but carbolic acid has the disadvantage of being expensive and somewhat difficult to dissolve.

CRUDE CARBOLIC ACID.

This substance should not be confused with pure carbolic acid. It is a product of coal-tar distillation and consists for the most part of practically inert oils and cresylic acid. Its disinfecting power depends upon the amount of cresylic acid which it contains, as well as upon the relative percentage of hydrocarbon oils. Owing to its uncertain composition, crude carbolic acid can not be classed as one of the most desirable disinfectants.

CRESOL.

Cresol, commonly termed "straw-colored carbolic acid," "liquid carbolic acid," etc., in a 2 per cent solution is an efficient disinfectant. It has the disadvantage, however, of being somewhat difficult to dissolve, so in preparing a disinfectant solution warm water should be used and care exercised that the drug is entirely dissolved. As the disinfecting power of cresol is dependent upon the amount of cresylic acid contained therein, it is essential when using the drug to know the degree of purity. Grades can be purchased under a guaranty to contain from 90 to 98 per cent of cresylic acid. Any containing less than 90 per cent should be rejected.

COMPOUND SOLUTION OF CRESOL.

Compound solution of cresol (*liquor cresolis compositus*), now recognized by the United States Pharmacopœia as an official preparation, is composed of equal parts of cresol (U. S. P.) and linseed-oil-potash soap. It is an efficient disinfectant in a $3\frac{1}{2}$ to 4 per cent solution and has the advantage of mixing readily with water.

"Saponified cresol solution" as prepared by various manufacturers is sometimes used as a substitute for compound solution of cresol (U. S. P.).

Under regulations of the Department of Agriculture only such preparations of "saponified cresol solution" as meet certain requirements are permitted for official disinfection of cars, boats, other vehicles, premises, etc. A list of such permitted disinfectants is furnished by the Bureau of Animal Industry, Washington, D. C., upon request.

DETAILS OF DISINFECTION.

In the practical work of disinfection there are three essentials:

1. A preparation of the building that will facilitate reaching organisms of disease.
2. A disinfectant which upon contact can be depended upon to destroy such organisms.
3. A method of applying the disinfectant that will assure the most thorough contact with the bacteria.

PREPARATION OF BUILDING.

Before beginning the use of a disinfectant it is essential that certain preliminary work be done in and about the stable that is to be treated. The various surfaces, such as ceiling, walls, partitions, floors, etc., should be swept until free from cobwebs and dust. Any accumulation of filth should be removed by scraping and scrubbing, using for this purpose a wire or other stiff brush and warm water with a liberal quantity of washing soda. In some cases the woodwork may have become softened and so porous as to be a good medium for the absorption of disease germs. Such woodwork should be removed, burned, and replaced with new material.

All refuse, manure, etc., from stable and barnyard should be removed to a place inaccessible to live stock and, if possible, be burned or thoroughly mixed with a solution of chlorid of lime in the proportion of 6 ounces to 1 gallon of water. If the floor is of earth, it will doubtless have become stained with urine and contaminated to a depth of several inches. In such cases 4 inches or more of the surface soil should be removed and treated as suggested above for refuse and manure. All earth removed should be replaced with soil from an uncontaminated source, or better, a new floor of concrete may be laid, this being the most durable and sanitary material for the purpose.

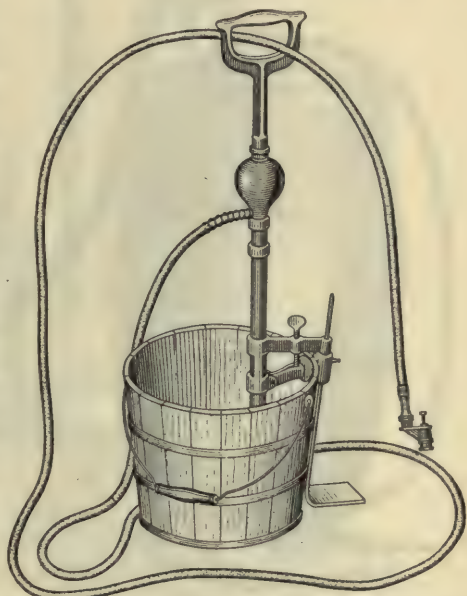


FIG. 3.—Pail spraying pump suitable for disinfecting small stables.

SELECTION AND PREPARATION OF THE DISINFECTANT.

Having made ready the field of operation, the next consideration should be the selection and preparation of the disinfectant. The fact must not be overlooked that many agents used for the destruction of bacteria are likewise poisonous to animals and man. In fact, some drugs, although powerful as germicides, are so poisonous as to preclude their general use in the work of disinfection. Among such, as previously stated, is bichlorid of mercury, which possesses the power of destroying not only bacteria, but spores as well. It is therefore essential in deciding upon an agent to select one having a known germicidal strength, properties of solubility, and at the same time possessing a reasonable degree of safety to animals and man.



FIG. 4.—A good type of barrel sprayer.

All things considered, it is probable that some of the coal-tar products best fulfill these requirements. In this class is the compound solution of cresol, already mentioned, a preparation recognized as official by the United States Pharmacopœia and known as *liquor cresolis compositus* (U. S. P.). This preparation mixes readily with water and will prove a very efficient disinfectant. It should be used in the proportion of at least 4 ounces to each gallon of water.

Another favorable agent is cresol (commercially known as

liquid carbolic acid). It is not so soluble as *liquor cresolis compositus* and should be stirred thoroughly during the process of mixing, which will be facilitated by using hot water. It is advisable to obtain a grade of the drug with a guaranty of 95 per cent pure, and such should be used in the proportion of 2 to 3 ounces to a gallon of water.

As an accessory preparation and for use after the application of the disinfectant it may be advisable to make ready a lime wash to each gallon of which there has been added 4 ounces of chlorid of lime, or if it appears desirable to use the disinfectant and lime wash at one application, the following method may be followed in preparing 5 gallons: Slake $7\frac{1}{2}$ pounds of lime, using hot water if necessary

to start action. Mix to a creamy consistency with water. Stir in 15 fluid ounces of cresol (commercially known as liquid carbolic acid) at least 95 per cent pure, and make up to 5 gallons by adding water. In case compound solution of cresol (*liquor cresolis compositus*) is used, add 30 fluid ounces instead of 15 as in the case of cresol (liquid carbolic acid). Stir thoroughly. If to be applied through a spray nozzle, strain through a wire sieve. Stir frequently when applying and keep covered when not in use.

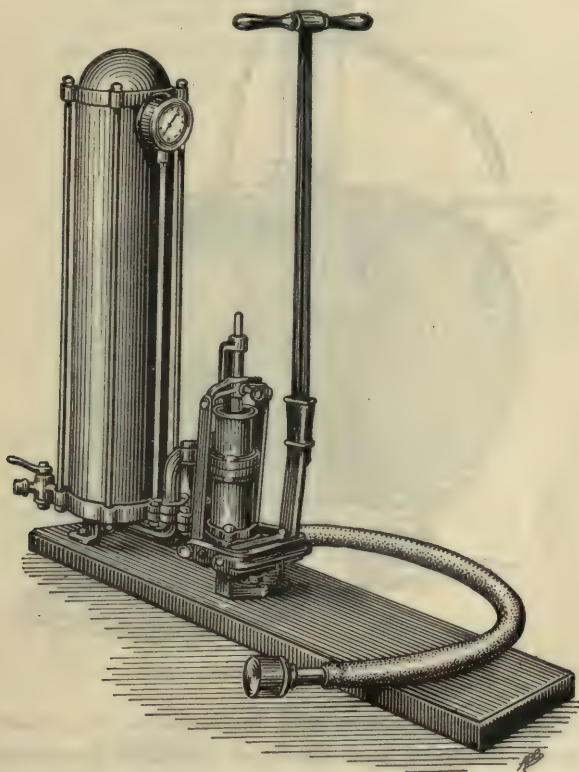


FIG. 5.—A double-acting sprayer, with air chamber.

In case a large surface is to be disinfected it will be advisable to prepare a liberal amount of the disinfecting solution before beginning the application. Such solutions, however, should not be permitted to remain in receptacles which are accessible to animals.

METHOD OF APPLICATION.

The efficacy and economy of the work will depend in a great measure upon the method of applying the disinfectant. Economy requires that the disinfecting solution be applied rapidly; efficiency requires that it be not only spread in such manner as to cover the entire surface requiring disinfection, but that sufficient quantity and force be used to drive the solution into all cracks and crevices.

Where a very limited surface is to be treated, as, for example, one stall, it may be possible to apply the disinfectant in a satisfactory manner by means of a whitewash brush. In all cases, however, the best method of applying the disinfectant and the lime wash is by means of a strong spray pump. Such should be equipped with not less than 15 feet of hose, to which may be attached a 5-foot section of iron pipe of the same caliber. With a spraying nozzle at the

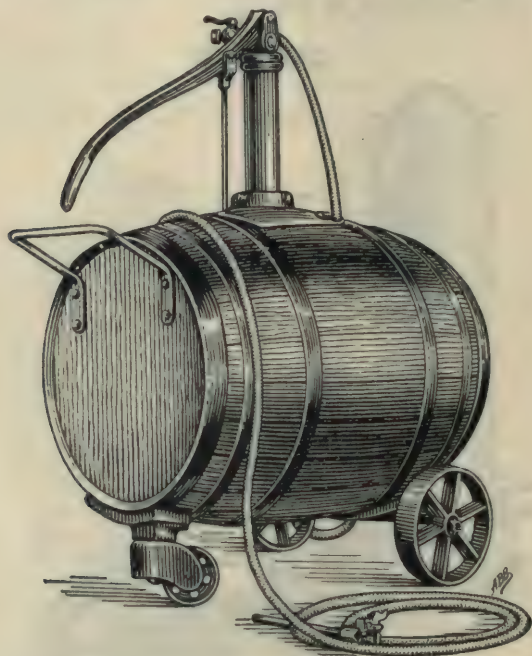


FIG. 6.—A whitewashing outfit.

end of the pipe the operator will be enabled to proceed with the greatest possible dispatch and the least possible inconvenience.

The entire interior of the stable should be saturated with the disinfectant. Special attention should be given to the feeding troughs and drains. After the disinfectant has dried, the surface may be sprayed with lime wash, provided this has not been combined with the disinfectant as previously described. When the work has been completed it will be advisable to open all doors and windows of the building for the admission of air and light.

USE OF WHEAT FLOUR SUBSTITUTES IN BAKING

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In cooperation with the Office of Home Economics



FARMERS' BULLETIN 955
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the States Relations Service

A. C. TRUE, Director

Washington, D. C.

March, 1918

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Division of Publications, United States Department of Agriculture

TO CONSERVE wheat is not a hardship to the American people. With abundant crops of corn, rice, potatoes, oats, barley, buckwheat, kafir, milo, feterita, peas, beans, peanuts, etc., any one of which may be used in larger or smaller amounts in place of wheat flour, there is no danger of hunger or a lack of bread. Every housewife, therefore, is urged to use some substitute for part of the wheat flour in whatever bread, biscuits, muffins, pastry, etc., she prepares, thereby joining the ranks of those who are helping to win the war. Such breads will have even greater nutritive value than if made from flour alone. In fact, many believe that for food purposes a mixture of different grains is better than one kind alone. In using wheat substitutes, therefore, locally grown products should be used as far as possible. All unnecessary shipment of materials should be avoided, so that transportation facilities may be reserved to the greatest degree for the needs of our soldiers and essential war business. Furthermore, almost every section of our country produces in abundance some crop other than wheat, and to market this at home rather than at a distance would prove an economic benefit to such localities.

The following pages suggest some of the ways in which substitutes for wheat flour may be used in baking.

USE OF WHEAT-FLOUR SUBSTITUTES IN BAKING.

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PARTIAL SUBSTITUTES FOR WHEAT FLOUR IN BREAD MAKING.

THOUGH wheat is the leading bread cereal, flour or meal made from any of the other grains, or from dried peas, beans, potatoes, nuts, etc., when mixed with a certain proportion of wheat flour, will make good bread.

As used in discussing food situation and other dietary problems, "wheat substitute" means any flour, meal, or other grain product, potato or other vegetable (raw or cooked), or similar food material which can be used alone or in combination with wheat flour for making bread, biscuit, pastry, and other similar foods, or which can be used in the diet to replace wheat foods, wholly or in part. Local food customs and the available supply will in large measure determine what the housekeeper will use, and her success in using them will depend largely upon her skill in planning meals and her ability to make palatable and satisfactory dishes from a wide variety of materials.

Common foods which can be so used to replace wheat in cooking and in meal planning include corn, barley, rice, rye, Kafir, milo, feterita, beans, soy beans, peanuts, potato, sweet potato, dasheen, banana, pumpkin, squash, etc. However, in choosing a wheat substitute one must consider not only the suitability of the food for the purpose, but also its relation to general questions on food conservation. Indeed, at the present time the term "wheat substitute" has come to be used in a restricted sense, meaning those foods out of the possible number of wheat substitutes which the United States Food

¹The material in this bulletin is based mainly on the results of a technical study of wheat flour substitutes carried on under the direction of Dr. J. A. LeClerc, of the Bureau of Chemistry.

Administration specifies as most advantageous for the purpose at a given time. The list so specified will vary from time to time according to market conditions and other factors which enter into the problem. The requirements of the Food Administration are made known in many ways and the housekeeper can keep herself informed by noting the statements which appear in the public press and by asking for information from her State food administrator and other local representatives of Food Administration work.

With wheat substitutes the bread texture is not so pleasing and the loaf usually smaller. However, as much as 25 per cent wheat substitute will yield a "light" yeast bread of good quality, while up to 50 per cent can be used to make excellent "quick" or hot breads. Most yeast breads are of larger volume and better texture and quality when made with cooked wheat substitutes (boiled or baked potatoes, corn-meal mush, cooked rice, etc.) than with raw foods. This suggests a new use for left overs.

Although special recipes are not necessary for using wheat substitutes, they are often convenient. The following are only a few of the many possible ones and merely suggest some combinations of food materials which will yield palatable breads. Shortening is omitted as not essential to yeast bread, milk (either whole or skimmed) if procurable is recommended, as it improves quality, and for some breads sirup is recommended in place of sugar. All measurements given are level.

YEAST BREADS.

General instructions.—To assure success in bread making it is important to maintain absolute cleanliness with regard to the materials used, as well as the utensils and the hands. The flour should be sound and free from foreign odor and taste.

Compressed yeast should be as fresh as possible and free from any odor other than the well-known yeasty odor. It should be fairly soft, but should break easily. It should never be mixed with any liquid which is more than lukewarm. Liquid yeast should always be kept covered and in a cool place. It should also have only a yeasty odor and should not be kept more than two weeks without freshening. During the summer season it is difficult to keep liquid yeast and in many places compressed yeast can not be secured. One cake of dry yeast will serve the same purpose as one of compressed yeast if the long-sponge process be used. Dry yeast must be soaked in water for 20 minutes to 1 hour before using to bring the yeast cells back to an active state. The use of dry yeasts calls for the long-fermentation method to give time for sufficient growth of yeast cells to make the dough light.

If milk (whole or skimmed) is used in bread making it should be scalded and cooled until lukewarm before adding it to the dough. In setting a sponge overnight it is better not to use milk.

If a sponge is set at night it should be kept at ordinary room temperature or less, depending upon how long it is to stand (from 60° to 75° F.). If the "straight-dough method" is used, or whenever a *dough* (as distinguished from a sponge) has been prepared, the temperature should be fairly warm, i. e., between 80° and 88° F. The time for rising required in the following recipes depends upon such temperature being maintained.

The dough should always be kept covered with a lid or plate, in order to prevent the formation of a crust on top. When thus covered it is unnecessary to grease the surface of the dough.

When molding the loaves a bit of dough¹ should be pinched off, shaped into a ball, and placed in a small jelly glass having straight sides. Its volume when placed in the glass should be noted and the glass marked at twice and three times this volume. This "indicator" should be set alongside the pans while the loaves are rising. When spring or hard winter wheat flours alone are used in bread making, the dough in the indicator should rise to three times the original volume and the loaves then be placed in the oven. When soft winter wheat flour is used, such as is generally found in the South, in the States east of the Mississippi, and on the Pacific coast, the indicator should show about two and a half times the original volume when the loaves are ready for baking.

For a so-called "standard" homemade loaf 1 cup liquid and about 3 to 3½ cups flour are required. The exact amount of flour for a given amount of liquid (or vice versa) can not be given in these recipes, since there is so much variation in this respect among different flours, and even in the same flour at different times. The most satisfactory pan for this amount of dough should hold 3 pints and would be approximately 7½ inches long and 3½ inches wide and 3½ inches deep. Bake loaves of this size about 50 minutes.

The heat of the oven should be about 425° F. at first and then gradually decreased until about 375° F. near the end of the baking. If no oven thermometer is at hand, test the oven by means of a little flour. Place 1 level teaspoon of flour in a small tin, like the lid of a jelly glass, spreading it in a layer about ¼ inch thick. Place this in the oven, and if the heat is right for bread baking the flour will become golden brown throughout within 5 minutes.² A pan of water

¹ This ball of dough should not be wasted. When it has served to show when the loaves are ready for the oven, place it in a small greased tin, let it stand about 15 minutes, then bake it while the loaves are still in the oven.

² This browned flour should be saved and used for thickening gravies or sauces.

in the oven during baking helps to give the bread a tender crust and prevents scorching.

After baking place the loaves on a cooling rack or else across the edges of the pans and allow to cool thoroughly. Do not cover meanwhile unless it is necessary to prevent contamination by dust or flies. When thoroughly cool, place the loaves in a perfectly clean, well-aired, and covered box of tin or aluminum or in a stone crock.

In making any of the breads which contain substances other than wheat flour it is possible to use either more or less of these substitutes than called for in the accompanying recipes. These recipes are based on the amounts which will make attractive loaves, both in appearance and in flavor. If more of the flour substitute is used, the volume of the loaves may be a trifle smaller, the texture will be a little poorer, and the flavor of the substitute will be more noticeable.

METHOD OF MAKING BREAD.

SHORT PROCESS OR STRAIGHT-DOUGH METHOD FOR WHEAT BREAD.

(Enough for four loaves.)

3 quarts (12 cups) sifted flour (more if necessary).	1 quart lukewarm liquid (water, milk, or equal parts of water and milk).
2 cakes compressed yeast or 1 cup liquid yeast.	4 teaspoons salt.

Flours vary so much in their ability to take up water that approximate quantities only can be given. In general, more than specified in these recipes will be required if a *soft* flour is being used.

When liquid yeast is used its volume must be included in the total liquid required.

Mix the yeast until smooth with a small amount of lukewarm liquid. Dissolve the salt in the rest of the liquid, add to the yeast, and mix thoroughly with the flour, so that all the latter may be worked in. Knead the mass until smooth and elastic, which will require not more than 10 to 15 minutes. Cover the bowl, place it in its warm place, and allow the dough to rise until light (about 1½ hours). In the case of a good bread flour the dough will have risen to about three times the original volume.

Cut down the dough from the sides of the bowl and knead. Should the dough be too soft, add a little flour at a time, kneading until it is smooth and elastic. If the dough be too stiff, add a little water, working it in well, and knead until the dough no longer sticks to the fingers or bowl. Cover and set aside in the same warm place until very light (one hour or more).

Cut down from the sides of the bowl and knead again just enough to expel the large bubbles of gas. Cut off a bit of dough to serve as an "indicator"; divide the rest into four equal portions, mold each quickly, stretching the outside of the loaf and pinching together underneath; place crease side down in lightly greased pans which have been warmed but are not hot. Set the loaves in the same warm place and allow to rise 50 minutes to 1 hour, or until the indicator shows two to three times the original volume, depending upon the kind of flour used. (See "indicator" on page 5.) Place in the oven and bake about 50 minutes. The oven should be at about 425° F. at first and may then decrease gradually until about 375° F.

LONG FERMENTATION METHOD—OVERNIGHT SPONGE.

(Enough for four loaves.)

3 quarts (12 cups) sifted flour (more if flour is soft).	1 quart lukewarm liquid.
1 cake yeast (dry or compressed), or $\frac{1}{2}$ cup liquid yeast.	4 teaspoons salt.

When liquid yeast is used its volume must be included in the total liquid required.

If dry yeast is used it should be soaked in some lukewarm water for 20 minutes to 1 hour before mixing with the flour. This amount of water will form part of the total liquid required for mixing.

In the evening measure out into the mixing bowl one-half the required amount of flour and, if the weather be cold, warm slightly. Mix the yeast, rubbed smooth, with two-thirds of the total amount of lukewarm liquid in which has been dissolved the salt. Add this yeast mixture to the flour, beat thoroughly, cover, and place where it will be at from 60° to 75° F. In weather moderately warm neither the flour nor the water need be heated. In hot weather it is better not to set a sponge overnight, since there is great danger of it turning sour before morning, unless the dough can be kept cool enough.

In the morning beat up the sponge thoroughly, add the remaining one-third of liquid, which may be warm enough to bring the temperature of the sponge up to 80° to 88° F. Next add the warmed flour and knead. Should the dough be too soft or too stiff, add flour or liquid, a little at a time, kneading it in thoroughly until a dough of the proper consistency is formed; knead until the dough is smooth and elastic and no longer sticks to the bowl or fingers. Cover and set where it will be kept at about 80° to 88° F. Allow to rise two hours, or until quite light.

From this point continue exactly as directed for molding and baking under "Straight-dough method."

SHORT SPONGE METHOD.

Many experienced bread makers believe that the sponge method yields a bread superior in texture and volume to that made by the straight-dough process, in which all the materials are mixed at once. It is well known, however, that a long fermentation, such as the overnight sponge, causes the bread to lose much of the sweet nutty flavor of the wheat, while the gluten of the flour used in the sponge becomes much weakened. With a short fermentation, however, the bread will have good texture and volume without loss of flavor. Slightly more labor is required to prepare bread by the sponge method than by the quick or straight-dough process.

Short sponge process: Blend $\frac{1}{2}$ to $\frac{1}{2}$ cake compressed yeast (or 4 tablespoons liquid yeast)¹ with 1 cup lukewarm liquid in which has been dissolved 1 teaspoon salt. Add this to 1½ cups sifted flour, mixing carefully to avoid lumping. Beat thoroughly until smooth, cover and set to rise in a moderately warm place (80 to 88° F.). When thoroughly light beat up this sponge, add to it the required amount of substitute ($\frac{3}{4}$ to 1 cup), and knead in enough more flour to make a dough of the proper consistency. Knead until smooth and elastic. Cover, allow to rise again, then knead down, mold into a loaf, and finish as usual.

¹ When liquid yeast is used its volume must be deducted from the total liquid.

BREAD FROM GENUINE WHOLE-WHEAT OR GRAHAM FLOUR.

When wheat is simply reduced to a meal by grinding it once or twice and not removing from it any bran, etc., it is known as Graham flour. This is genuine whole-wheat flour and might well be termed "wheat meal." Our ordinary flour consists of only about 75 per cent of the whole wheat, 25 per cent or more being removed by sifting and bolting and sold for stock feed as bran, shorts, etc. If, then, we use Graham flour in baking, or this 100 per cent wheat meal, it is equivalent to a mixture of 75 per cent of ordinary flour and 25 per cent of flour substitute.

Some housewives find it difficult to get Graham flour, even though wheat may be grown locally. If one does not object to the labor required, one may prepare her own wheat meal with the aid of a hand gristmill,¹ such as is used for grinding chicken feed. The wheat should first be washed quickly, then thoroughly dried, and ground to any desired fineness as needed.

GRAHAM OR WHOLE-WHEAT BREAD.

(1 loaf.)

3 cups or more Graham flour or wheat meal.	$\frac{1}{4}$ to $\frac{1}{2}$ cake yeast (dry or compressed), or
$1\frac{1}{2}$ cups lukewarm liquid.	2 to 4 tablespoons liquid yeast (deduct from other liquid).
1 teaspoon salt.	
2 tablespoons sirup.	

Short process.—Dissolve the salt and sirup in 1 cup lukewarm liquid, and to this add $\frac{1}{2}$ cake compressed yeast blended with $\frac{1}{4}$ cup lukewarm water (or 4 tablespoons liquid yeast). Mix with this sufficient Graham flour to form a dough not too stiff. Knead until smooth and elastic. Cover and allow to rise until quite light (at least double in bulk). Knead down, mold, place in greased pan, and allow to rise until just double in volume. Bake at least one hour in a moderately hot oven. If desired the dough may be allowed to rise twice before being molded for the pan.

Long process.—Make a sponge of $\frac{3}{4}$ cup lukewarm liquid, 1 teaspoon salt, $\frac{1}{4}$ cake yeast (dry² or compressed), blended with $\frac{1}{4}$ cup lukewarm water (or 2 tablespoons liquid yeast), and $1\frac{1}{2}$ cups Graham flour. Cover and let rise overnight or until very light. In the morning break up this sponge, add $\frac{1}{4}$ cup liquid at about 90° F. and 2 tablespoons sirup, and enough more Graham flour to make a dough not too stiff. Knead until smooth and elastic. Mold and finish as directed above, or allow to rise a second time before molding.

QUICK GRAHAM-KAFIR OR RICE ROLLS.

(12 rolls.)

2 cups Graham flour.	2 tablespoons sirup.
1 cup Kafir flour or ground rice.	1 tablespoon shortening (melted).
1 cup (or more) lukewarm liquid.	$\frac{1}{4}$ to $\frac{1}{2}$ cake yeast (dry or compressed), or 2 to 4 tablespoons liquid yeast.
1 teaspoon salt.	

Make a sponge with $1\frac{1}{2}$ cups Graham flour, 1 cup lukewarm liquid, the salt, and yeast. Cover and allow to rise until quite light. Break up this sponge,

¹ Such a mill will be found convenient for grinding many other materials, such as corn, rye, soy beans, etc. Meals of any desired fineness may thus be obtained, with the full flavor of the fresh material.

² When dry yeast is used it must be soaked in a portion of the liquid and soaked for 20 minutes to 1 hour before adding to the sponge.

add to it the sirup, the shortening, 1 cup kafir or rice flour, and the remaining $\frac{1}{2}$ cup Graham flour. If necessary add enough more liquid to form a soft dough (as for drop biscuits). Beat until smooth and drop at once into greased muffin pans (half full). Let rise until just double in bulk, then bake about 25 to 30 minutes in a moderate oven.

Other substitutes, such as rolled oats, buckwheat, barley, feterita, etc., may be used in place of the kafir.

BREAD MADE WITH WHEAT SUBSTITUTES.

CORN-MEAL BREAD.

(One loaf.)

1 cup corn meal.	1 cup (or more) lukewarm liquid.
3 cups wheat flour.	$\frac{1}{2}$ to $\frac{1}{2}$ cake yeast, dry or compressed,
1 teaspoonful salt.	or 2 to 4 tablespoonfuls liquid yeast.
1 tablespoonful sirup, if desired.	

Short process.—Sift together the flour and meal. Mix $\frac{1}{2}$ cake compressed yeast or 4 tablespoonfuls of liquid yeast with a little of the lukewarm liquid and add to it the remainder of the liquid, in which has been dissolved the salt (and the sirup if used). Blend this yeast mixture with the dry material until all the latter is incorporated, using a little additional liquid if necessary. Cover and set to rise. When light knead down, mold, and finish as usual or allow to rise a second time until light before molding and placing in pan.

Long process.—Make a sponge of $1\frac{1}{2}$ cups wheat flour, $\frac{1}{2}$ cup lukewarm liquid in which has been dissolved 1 teaspoonful salt and 2 tablespoonfuls of liquid yeast or $\frac{1}{2}$ cake yeast, dry or compressed, blended with $\frac{1}{4}$ cup lukewarm water. Cover and set to rise over night. In the morning (or when thoroughly light) add $\frac{1}{4}$ cup water at about 90° F., the sirup if desired, and the sifted mixture of 1 cup corn meal and $1\frac{1}{2}$ cups wheat flour. Knead thoroughly until a smooth elastic dough is formed, adding a little more liquid if necessary. Cover and allow to rise until quite light. Knead down, mold into a loaf, and finish as usual. Any other finely ground meal or flour made from corn may be used in place of corn meal.

ROLLED-OATS BREAD.

(1 loaf.)

$\frac{3}{4}$ cup (packed) rolled oats.	1 tablespoon sirup if desired.
$2\frac{1}{4}$ cups (or more) wheat flour.	$\frac{1}{2}$ to $\frac{1}{2}$ cake yeast (dry or compressed),
1 cup liquid.	or 2 to 4 tablespoons liquid yeast
1 teaspoon salt.	(deduct from total liquid).

Scald the oats with $\frac{3}{4}$ cup boiling water in which have been dissolved the salt and sirup; cover and allow to cool until lukewarm. Blend the yeast cake with $\frac{1}{4}$ cup lukewarm liquid (or use liquid yeast); add to the cooled oats and work in as much of the flour as possible. Cover and set to rise until light. If the dough seems soft at this time, work in enough more flour until of the proper consistency. Knead until fairly smooth and elastic. Cover and let rise again. When quite light knead down, mold, place in greased pan, and allow to rise until about $2\frac{1}{2}$ times its bulk, according to the "indicator." Bake about one hour in a moderate oven.

Corn meal may be used in place of the oats in the above recipe.

BARLEY OR BUCKWHEAT BREAD.

(1 loaf.)

$\frac{3}{4}$ cup barley or buckwheat¹ flour.
 2 $\frac{1}{4}$ cups (or more) wheat flour.
 1 cup lukewarm liquid.
 1 teaspoon salt.
 1 tablespoon sirup (if desired).

$\frac{1}{4}$ to $\frac{1}{2}$ cake yeast (dry or compressed).
 or
 2 to 4 tablespoons liquid yeast (deduct
 from total liquid).

Short process.—Dissolve the salt in the cup of liquid and mix with this one-half cake compressed yeast blended with a little of the liquid, or 4 tablespoons liquid yeast. Add this yeast mixture to the well-blended flours, stirring until well mixed. Cover and allow to rise until light (at least double in volume). Knead thoroughly, cover, and let rise a second time. When quite light knead down, mold, place in greased pan, and let rise in pan until two and one-half times its bulk, according to the "indicator." Bake 50 minutes to 1 hour.

Long process.—Make a sponge of $\frac{1}{2}$ cups wheat flour, 1 cup lukewarm liquid, 1 teaspoon salt, and $\frac{1}{4}$ cake yeast, dry or compressed (or 2 tablespoons liquid yeast). Beat thoroughly, cover, and let rise over night or until quite light. Break up this sponge, add the barley or buckwheat flour and enough more wheat flour to make a dough of medium stiffness. Knead until smooth and elastic. Cover and let rise until very light. Knead down, mold, and finish as directed under short process above.

PEANUT BREAD.

(1 loaf.)

1 cup lukewarm liquid.
 1 teaspoon salt.
 3 cups flour (more if necessary).
 1 or 2 tablespoons sirup.
 1 cup peanut meal or peanut flour.²

$\frac{1}{4}$ to $\frac{1}{2}$ cake yeast (dry or compressed).
 or
 2 to 4 tablespoons liquid yeast (deduct
 from other liquid).

Short process.—Dissolve the salt and sirup in the cup of lukewarm liquid. Mix with it the compressed yeast ($\frac{1}{2}$ cake) blended with a small portion of the liquid or 4 tablespoons liquid yeast, and add all to the mixture of flour and peanut meal. Knead until smooth and elastic, adding more flour or liquid, if necessary, to secure proper consistency. Cover and let rise until quite light. If desired, knead down and let rise a second time until very light. Then knead lightly, pinch off a bit for the indicator, mold the rest, place in greased pan, cover and let rise until at least two and one-half times the original bulk. Bake 50 to 60 minutes in a moderately hot oven (400° F).

Long process.—Make a sponge of $\frac{1}{2}$ cup lukewarm liquid, 1 teaspoon salt, $\frac{1}{4}$ cake yeast, dry or compressed, dissolved in $\frac{1}{4}$ cup lukewarm water (or 2 tablespoons liquid yeast), and $1\frac{1}{2}$ cups flour. Beat well, cover and set aside where it will be between 60° and 70° F. if possible. When thoroughly light add to this sponge $\frac{1}{4}$ cup water at about 90° F. to which has been added the sirup, and the mixture of peanut meal and $1\frac{1}{2}$ cups flour. Knead until smooth and elastic, adding more flour or liquid if necessary. Cover and set aside until quite light. Then knead down, mold, and finish as directed under the short process.

Any other dry meal or flour obtained from corn, rice, kafir, milo, feterita, millet, chick pea, navy beans, peas, chestnuts, bananas, dasheen, or cassava

¹ In yeast bread the plain buckwheat flour, not self-rising buckwheat flour, should be used.

² Peanut meal may be prepared by shelling roasted peanuts, removing red skin, and crushing the nuts with a rolling pin or putting them through a food chopper.

may be used in place of the peanut meal in the above recipe. Somewhat more liquid will probably be required with these other meals than when peanut is used.

POTATO BREAD.

(One loaf.)

1 cup mashed sweet or Irish potatoes.	2½ cups or more sifted flour.
1 teaspoon salt.	¾ to 1 cake yeast (dry or compressed),
1 tablespoon sirup, if desired.	or 2 to 4 tablespoons liquid yeast. ¹
4 tablespoons lukewarm water.	

Use left-over boiled or baked potatoes or boil potatoes in their skins until tender. Peel and mash the potatoes or put them through a colander or ricer to free them from lumps.

Short process.—To 1 cup of the cool mashed potato add 1 teaspoon salt, 1 tablespoon sirup, and ½ cake compressed yeast mixed with 4 tablespoons lukewarm water, or 4 tablespoons liquid yeast. Mix with this ½ to 1 cup sifted flour, stirring until thoroughly blended. Cover and allow to rise until soft and light (about 2 hours). Knead in enough more flour to make a dough somewhat stiffer than for white bread. If the potatoes are rather dry or mealy, a little additional water may be required. Knead until smooth and elastic. Cover and let rise again until very light. Then knead down, mold and finish as usual. Allow to rise in the pan until two and one-half to three times the original bulk. Bake slowly in a moderately hot oven at least 50 minutes.

Long process.—To 1 cup of the cool mashed potatoes add 1 teaspoon salt and ½ cake yeast, dry or compressed, mixed with 4 tablespoons lukewarm water, or 2 tablespoons liquid yeast. Add to this ½ to 1 cup sifted flour, cover and set to rise where it will be between 60° to 70° F. When thoroughly light and soft add to it the sirup and knead in enough more flour to form a smooth, elastic, and rather stiff dough. Cover and allow to rise again until very light. Then knead down, mold, and finish as directed under short process.

Cooked or baked squash, pumpkin, peas, beans, or dasheen may be used in place of the potato.

More potato (or other cooked substitute) may be used and less water. E. g., with 1½ cups mashed potato only 2 tablespoons water per loaf are required. Less flour also will be needed.

RICE BREAD.

(1 loaf.)

1 cup boiled rice.	2½ cups or more sifted flour.
1 teaspoonful salt.	¾ to 1 cake yeast (dry or compressed),
1 tablespoon sirup, if desired.	or 2 to 4 tablespoons liquid yeast. ¹
4 tablespoons lukewarm water.	

Left-over rice may be used, or broken rice may be especially cooked for this purpose, using one-half cup uncooked rice with 1 cup water for each loaf to be made. Cook rice until very tender, and, if desired, put it through a ricer or colander.

Follow directions given under potato bread, using cooked rice instead of the potato.

¹ When liquid yeast is used it must be included in the total liquid.

CORN-MEAL MUSH BREAD.

(1 loaf.)

1 cup corn-meal mush, cooked grits, or fine hominy.	4 tablespoons lukewarm water.
1 teaspoon salt.	2½ cups or more sifted flour.
1 tablespoon sirup, if desired.	½ to ½ cake yeast (dry or compressed), or 2 to 4 tablespoons liquid yeast. ¹

Use left-over mush, grits, or fine hominy, or prepare a mush from two-thirds cup dry corn meal and 1½ cups water. Cook 10 minutes to one hour in a double boiler, or in a vessel placed in another containing boiling water. Cool the mush until lukewarm, then follow directions for making bread given under potato bread, substituting corn-meal mush for the potato.

Any other cooked cereal, either prepared for this purpose or left-over portions, may be used in place of the corn-meal mush. If the cereal has been previously salted use only two-thirds teaspoon salt per loaf.

SOY-BEAN BREAD.

(1 loaf.)

1 cup soy-bean meal or flour.	½ to ½ cake yeast (dry or compressed), or 2 to 4 tablespoons liquid yeast (deduct from other liquid).
3 cups sifted flour (more if necessary).	
1 teaspoon salt.	
1 tablespoon sirup.	
1 cup lukewarm liquid (more, if necessary).	

Short process.—Dissolve the salt and sirup (if used) in three-fourths cup of liquid; heat this to boiling and pour it over the soy-bean meal, mixing thoroughly. Let stand until lukewarm; add to it the compressed yeast (one-half cake), blended with one-fourth cup lukewarm liquid or 4 tablespoons liquid yeast, and the flour. Knead until smooth and elastic. Cover and let rise in a moderately warm place until quite light. Knead lightly, mold, place in greased pan, cover, and let rise until just double in bulk. Bake 50 to 60 minutes in a moderately hot oven (400° F.), reducing the heat at the end of the first 10 or 15 minutes.

Long process.—Follow directions given for peanut bread (long process), using soy-bean meal in place of the peanut. After molding the soy-bean loaf let it rise in the pan only until double in volume. Bake slowly in a moderately hot oven 50 to 60 minutes.

The addition of raisins or chopped dates to this loaf makes a delicious bread.

LIGHT ROLLS WITH DRY WHEAT SUBSTITUTES.

(Enough for 12 small rolls.)

2½ cups sifted flour (more if necessary).	2 tablespoons lukewarm water.
¾ cup wheat substitute (corn meal, corn or rice flour, rye, oatmeal, soy-bean meal, peanut meal, kafir, milo, etc.).	1 teaspoon salt.
1 cup milk (or part milk and part water).	2 tablespoons sirup.
	1 tablespoon shortening.
	½ cake yeast (dry or compressed), or ¼ cup liquid yeast.

¹ When liquid yeast is used it must be included in the total liquid.

Scald the milk, and while hot dissolve in it the salt, sirup, and shortening. When cooled until lukewarm, add to this the yeast rubbed smooth with 2 tablespoons lukewarm water. (When liquid yeast is used, its volume must be deducted from the total liquid. If dry yeast is used it should be soaked for an hour in the 2 tablespoons of water before adding it to the other ingredients.)

Measure into a bowl $1\frac{1}{2}$ cups of sifted flour and add to this gradually the mixture of milk, salt, sirup, shortening, and yeast, so that it will be free from lumps. Beat well, cover, and set aside to rise.

When this sponge is quite light beat until smooth and add to it gradually the mixture of $\frac{1}{4}$ cup of flour and $\frac{1}{4}$ cup of wheat substitute, sifted together. Knead until a smooth, elastic dough is formed, adding more flour if required. Cover and set aside to rise. When very light, knead again until smooth. Cut or break off small pieces about the size of a hen's egg, roll between the palms of the hands until round and smooth, and place in greased biscuit tins, not too closely together. Reserve one piece for an indicator. Allow to rise in the pans until $2\frac{1}{2}$ or 3 times the original volume, and bake in a moderately hot oven 20 to 25 minutes.

LIGHT ROLLS WITH COOKED SUBSTITUTES.

(About 12 small rolls.)

When the sponge made with cooked materials, such as potatoes,¹ rice, corn meal, oatmeal, etc., is light, add to a one-loaf portion 1 tablespoon melted shortening and 2 tablespoons sirup. Knead in thoroughly enough flour to make a smooth, elastic dough. Let rise again until very light. Knead down, break or cut off small pieces the size of an egg, roll between the palms of the hands until round and smooth, and place not too closely together in greased biscuit tins. Allow to rise until $2\frac{1}{2}$ or 3 times the original volume, then bake in a moderately hot oven about 25 minutes, or until well done within.

Bake all bread containing cooked substitutes a little more slowly and longer than ordinary breads.

QUICK OR HOT BREADS.

In any of the following recipes sour milk or buttermilk and soda may be substituted for sweet milk (or water) and baking powder. To guard against an excess of soda, which causes a yellow color in the bread and a less agreeable flavor, use one-half to three-fourths level teaspoonful of soda to every cupful of sour milk. The soda may be sifted with the other dry ingredients, as is recommended when using baking powder, insuring thorough mixing and less loss of leavening gas.

In using either baking powder or sour milk and soda, all materials should be as cold as possible, especially the liquid, and (in case of biscuits) the shortening as well.

The mixing should be done as quickly as possible, especially after the baking powder is moistened, to minimize the loss of leavening gas. Biscuits should be rolled, cut, and placed in the pans as soon as possible after mixing. If necessary, they may stand in the pans before baking with comparative safety.

¹ See directions for potato bread, p. 11.

BISCUITS.

FIFTY PER CENT FLOUR SUBSTITUTE BISCUIT.

Any meal or flour made from corn, rice, oats, rye, barley, kafir, milo, feterita, soy bean, peanuts, chestnut, dasheen, sweet potato, Irish potato, etc., may be used as a substitute.

2 cups of any of the substitutes mentioned above.	2 teaspoons salt.
2 cups wheat flour.	4 tablespoons shortening.
4 teaspoons baking powder. ¹	Liquid sufficient to mix to proper consistency (1 to 1½ cups). ²

Sift together the flour, meal,² salt, and baking powder twice. Have the shortening as cold as possible and cut it into the mixture with 2 knives, finally rubbing it in with the hands. Mix quickly with the cold liquid (milk, skim milk, or water), forming a fairly soft dough which can be rolled on the board. Turn onto a floured board; roll into a sheet not over ½ inch thick; cut into rounds; place these in lightly floured biscuit tins (or shallow pans), and bake 10 to 12 minutes in a rather hot oven.

CORN-MEAL, PEANUT, AND WHEAT BISCUITS.

1 cup corn meal.	2 teaspoons salt.
1 cup peanut meal (soy-bean meal may be used instead).	4 teaspoons baking powder.
	3 tablespoons shortening.
Liquid sufficient to mix (1 to 1½ cups).	2 cups wheat flour.

Mix, roll, cut, and bake as directed for 50 per cent substitute biscuits.

WHEAT-MEAL BISCUITS.

4 cups Graham flour or home-ground wheat meal.	2 tablespoons sirup, if desired.
2 teaspoons salt.	4 tablespoons shortening.
4 teaspoons baking powder.	Liquid sufficient to mix (about 1½ cups).

Mix, roll, cut, and bake as directed for 50 per cent substitute biscuits.

CORN MEAL-GRAHAM BISCUITS.

1 cup Graham flour (or home-ground wheat meal).	1½ teaspoons salt.
1 cup corn meal.	1 tablespoon sirup or molasses.
1 cup sifted wheat flour.	3 teaspoons baking powder. ¹
Liquid sufficient to mix (1 to 1½ cups).	3 tablespoons shortening.

Mix, roll, cut, and bake as directed for 50 per cent substitute biscuits.

Other variations may be made by replacing the corn meal in the above by soy-bean meal, rice polish, shorts from wheat, or any of the substitutes named above.

POTATO BISCUITS.

2 cups sifted flour.	1 cup mashed potato.
1 teaspoon salt.	3 tablespoons shortening.
3 teaspoons baking powder.	Liquid sufficient to mix.

¹ In place of baking powder and sweet milk or water, ¾ to 1 teaspoon of baking soda and 1½ cups sour milk or buttermilk may be used.

² In using peanut meal the flour and other dry ingredients should be sifted together twice and then mixed thoroughly with the peanut meal. Roasted and shelled peanuts may be crushed with a rolling pin and used in place of peanut meal.

Sift together twice the flour, salt, and baking powder. Cut or rub into this the cold shortening. In the same way rub into this flour mixture the mashed potato. Finally add just enough cold liquid to make the mass cling together. Do not knead. Place on floured board, roll until $\frac{1}{2}$ inch thick, cut into rounds. Place these in lightly floured biscuit tins and bake 15 to 20 minutes in a moderately hot oven. Bake all potato breads more slowly than those made with flour alone.

GEMS.

ENTIRE CORN-MEAL OR WHEAT-MEAL GEMS.

2 cups corn meal or wheat meal (Graham flour).	1 egg.
1 teaspoon salt.	1 tablespoon shortening.
2 tablespoons sirup.	Liquid to mix to a medium batter (1 to
2 teaspoons baking powder.	$1\frac{1}{2}$ cups).

Sift together the meal, salt, and baking powder twice, returning the bran, which has been retained on the sifter, to the mixture and blending it thoroughly. To this mixture of dry ingredients add the beaten egg, the melted shortening, sirup, and milk (or water) enough to make a batter of medium consistency. Drop by spoonfuls into greased muffin or gem pans. These should be about half full. Bake 18 to 20 minutes in a fairly hot oven.

CORN, WHEAT, SOY-BEAN GEMS.

(24 small gems.)

1 cup corn meal.	2 tablespoons sirup.
1 cup wheat meal (Graham flour).	2 tablespoons shortening.
1 cup soy-bean meal.	1 egg.
$1\frac{1}{2}$ teaspoons salt.	Liquid to mix to a medium batter
3 teaspoons baking powder. ¹	(about $1\frac{1}{2}$ cups). ¹

Follow directions given under entire Corn-Meal Gems for mixing and baking.

Other varieties may be made by substituting in the latter recipe peanut meal, oatmeal, rice flour, rice polish, or rye flour for soy-bean meal.

BUCKWHEAT OR BARLEY FLOUR GEMS.

1 cup buckwheat or barley flour.	1 or 2 tablespoons sirup.
1 cup whole wheat or Graham flour.	1 tablespoon shortening (melted).
1 teaspoon salt.	1 egg,
3-teaspoons baking powder. ²	Liquid (about 1 to $1\frac{1}{2}$ cups). ²

Mix and bake as directed under Cornmeal Gems. Any other flour or meal may be used in place of buckwheat or barley in the above recipe.

¹ In place of the baking powder and liquid, such as sweet milk or water, $\frac{3}{4}$ to 1 teaspoonful of baking soda and $1\frac{1}{2}$ cups of sour milk or buttermilk may be used.

² In place of baking powder and sweet milk, $\frac{3}{4}$ teaspoon soda and 1 to $1\frac{1}{2}$ cups sour milk may be used.

BROWN BREAD.**BROWN BREAD—BOSTON STYLE.**

(1 loaf.)

1 cup cornmeal.	1 teaspoon soda.
1 cup soy bean meal (or other substitute).	$\frac{1}{2}$ cup sirup.
1 cup Graham or whole wheat flour.	$\frac{3}{4}$ cup raisins.
$1\frac{1}{2}$ teaspoons salt.	2 cups sour milk.

Sift together the meals, flour, salt, and soda. Blend with this mixture the raisins, which have been seeded and cut. Add the sirup and enough sour milk (about 2 cups) to make a rather thick batter. Pour it into a greased container with tight lid, such as a coffee can or large baking-powder can. Do not have the container much more than half full. Tie on the lid and steam for 3 hours. It is excellent when baked in a fireless cooker.

CORN BREAD.**EGGLESS CORNBREAD.**

(12 servings.)

2 cups cornmeal.	1 tablespoon sirup.
1 teaspoon salt.	2 tablespoons shortening.
3 teaspoons baking powder, 1 cup sweet milk, or	
$\frac{3}{4}$ teaspoons baking soda, 1 to $1\frac{1}{2}$ cups sour milk.	

Sift together the cornmeal, salt, baking powder (or soda). Dissolve the sirup in the milk and add this to the sifted dry ingredients. Finally add the melted shortening, beat well and pour into a greased shallow tin. Bake 25 to 30 minutes in a moderately hot oven.

BATTER OR SPOON BREAD.

$1\frac{1}{2}$ cups corn meal.	1 cup milk and 1 cup water.
1 teaspoon salt.	1 egg (or 2).
1 tablespoon sirup, if desired.	1 tablespoon shortening (melted).
2 cups milk, or	2 teaspoons baking powder.

Place milk (or milk and water), salt, and meal in double boiler, or in a vessel placed in hot water, and cook for 5 to 10 minutes. Allow to cool, beating until smooth. Add the sirup, shortening, well-beaten egg, and baking powder, beating very thoroughly. Pour into a greased pan and bake about 25 minutes in a moderately hot oven.

MUFFINS.**POTATO MUFFINS.**

$1\frac{1}{2}$ cups cooked sweet potato (Irish potatoes may be used instead, with or without the sugar).	2 tablespoons sirup, if desired.
$1\frac{1}{2}$ cups wheat flour.	1 or 2 eggs.
1 teaspoon salt.	2 tablespoons shortening.
3 teaspoons baking powder.	Liquid sufficient to make a rather stiff batter (about $\frac{1}{2}$ cup).

Boil the potatoes in the skins until tender; drain, peel, and mash fine. Putting the potato through a ricer or colander is better than mashing. Sift

together the flour, salt, and baking powder twice. Beat the eggs until light and add to the cool mashed potato. Next add the sirup and the melted shortening, then the flour mixture, alternating with portions of the liquid, until a batter is formed somewhat stiffer than for ordinary flour muffins. Drop by spoonfuls into greased muffin pans until half filled and bake 25 to 30 minutes in a moderately hot oven.

SOY BEAN, RICE, OATMEAL, CORN MEAL, OR DASHEEN MUFFINS.

In the above recipe replace the cooked potato with any cooked cereal, such as rice, oatmeal, corn meal, or with cooked soy-bean meal, cooked or baked dasheen, etc. When using any substance containing cooked starch it is necessary to have the batter rather stiffer than for wheat-flour muffins.

POTATO-CORN MEAL MUFFINS.

(15 muffins.)

1 cup mashed sweet or Irish potato.	2 tablespoons sirup.
1 cup corn meal.	2 tablespoons shortening.
$\frac{1}{2}$ cup sifted flour.	1 or 2 eggs.
$1\frac{1}{2}$ teaspoons salt.	Liquid to mix to a medium batter
3 teaspoons baking powder.	($\frac{1}{2}$ to $\frac{3}{4}$ cup).

Add the corn meal, salt, sirup, and $\frac{1}{2}$ cup liquid to the hot mashed potato, place in double boiler, and steam 10 minutes. Add the shortening and allow to cool thoroughly. When cold add the well-beaten eggs and the flour, which has been sifted with the baking powder. Add enough more liquid, if necessary, to make a somewhat stiff batter. Beat thoroughly, place in gem pans until half filled, and bake about 25 minutes in a moderately hot oven.

BREAD MUFFINS.

$1\frac{1}{2}$ cups dry bread crumbs.	1 egg.
1 cup milk.	1 tablespoon shortening.
$\frac{1}{2}$ teaspoon salt.	2 tablespoons sirup.
2 teaspoons baking powder.	$\frac{1}{2}$ cup flour.

Scald the milk, add the crumbs, allow to stand 15 minutes, then mash and beat to a paste. Add the salt, sirup, beaten egg yolk, melted shortening, and the flour and baking powder sifted together. Finally fold in the beaten egg white. Pour into gem pans until half filled, then bake about 20 minutes in a moderately hot oven.

PUMPKIN-CORN MEAL DODGERS.¹

$1\frac{1}{2}$ cups cooked pumpkin.	3 tablespoons shortening.
1 teaspoon salt.	2 tablespoons sirup.
$1\frac{1}{2}$ cups corn meal.	

To the pumpkin, which has been cooked very tender and mashed free from lumps, add the salt, sirup, melted shortening, and corn meal and mix thoroughly. Have the mixture just soft enough to take up by spoonfuls and pat into flat cakes in the hand. Place on a griddle or greased baking sheet and bake about 20 minutes in a hot oven.

If desired, the corn meal may be added to the hot pumpkin and allowed to steam with the latter for 10 minutes before adding the other ingredients.

¹ Based on an old southern recipe handed down through several generations.

SWEET POTATO-CORN MEAL DODGERS.

Substitute cooked or baked sweet potato for the pumpkin in the previous recipe, adding a little liquid, if necessary, to give the required consistency.

DUMPLINGS.

CORN MEAL DUMPLINGS.

(To serve with stews, smothered chicken, etc.)

3 tablespoons corn meal or corn flour.	1 teaspoon baking powder.
6 tablespoons wheat flour.	1 egg.
$\frac{1}{2}$ teaspoon salt.	Milk if necessary.

Sift together the flour, meal, salt, and baking powder. Beat the egg very light and add to the dry materials. Add milk, if necessary, until a soft mixture as for muffins is formed. Drop by teaspoonfuls into the vessel containing the boiling stew. Cover the vessel and steam about 10 minutes without removing the lid.

GRIDDLE CAKES.

BREAD GRIDDLE CAKES.

1 $\frac{1}{2}$ cups dry bread crumbs.	1 egg.
1 $\frac{1}{2}$ cups sweet milk. ¹	1 tablespoon shortening.
$\frac{1}{2}$ teaspoon salt.	$\frac{1}{2}$ cup flour.
1 tablespoon sirup.	2 teaspoons baking powder. ¹

Scald the milk, add the crumbs, let stand 15 minutes, then mash and beat to a paste. Add the salt, sirup, melted shortening, and well-beaten egg. Finally add the flour and baking powder, which have been sifted together. Bake on a hot griddle until nicely browned on both sides.

CORN MEAL-GRAHAM GRIDDLE CAKES.

1 cup corn meal.	1 teaspoon baking soda.
1 cup Graham flour or wheat meal.	1 egg.
1 teaspoon salt.	2 tablespoons hot water.
1 tablespoon sirup.	2 cups sour milk.

Scald the meal with a little boiling water in which has been dissolved the salt; cover and allow to cool. When cold add to it the sirup, the well-beaten egg, one cup of the milk, then the Graham flour, the soda dissolved in the hot water, and lastly the remaining milk, or enough to yield a batter which will pour easily, but is not too thin. Beat thoroughly. Bake until well browned on both sides.

POTATO-CORN MEAL GRIDDLE CAKES.

1 cup mashed potato.	1 tablespoon sirup.
1 cup corn meal.	1 tablespoon shortening (melted).
$\frac{1}{2}$ cup flour.	1 egg.
1 teaspoon salt.	Liquid sufficient.
2 teaspoons baking powder.	

Add the salt, sirup, and one-half cup milk or water to the mashed potato, then blend with this the corn meal. Heat and stir frequently until the meal is scalded or cook for about five minutes. Remove from the fire and cool. When cold

¹ In place of baking powder and sweet milk alone, $\frac{1}{2}$ cup sweet milk may be used to moisten the crumbs and 1 cup of sour milk with $\frac{1}{2}$ teaspoon baking soda for thinning and leavening the mixture.

add to this mixture the shortening, the well-beaten egg, the flour and baking powder sifted together, and enough liquid (milk or water) to make a medium batter, not too thin. Bake slowly and thoroughly.

WAFERS, COOKIES, ETC.

FIFTY PER CENT SOY-BEAN WAFERS.

- | | |
|------------------------|----------------------------|
| 1½ cups soy-bean meal. | 2 teaspoons baking powder. |
| 1½ cups sifted flour. | 3 tablespoons sugar. |
| 1 teaspoon salt. | 2 tablespoons shortening. |
| ½ cup sirup. | |

Sift together the flour, soy-bean meal, salt, and baking powder twice. Cream together the sugar, sirup, and shortening. Alternately add the flour mixture and a little milk until the dough is of such consistency that it can be rolled on the board. Turn onto a floured board; roll very thin (about ⅛ inch thick); cut with a biscuit cutter; place in greased shallow pans and bake 10 minutes in a fairly hot oven or until a delicate brown.

FIFTY PER CENT PEANUT WAFERS.

- | | |
|-------------------------------|--------------------------------------|
| 2 cups Graham flour. | 1 egg. |
| 1½ cups crushed peanut meats. | ¾ cup sirup with 2 tablespoons sugar |
| 1 teaspoon salt. | (or ¾ cup honey). |
| 2 teaspoons baking powder. | 2 tablespoons shortening. |

Sift the salt and baking powder with the flour, returning the bran to the mixture, and mix with this the peanuts which have been lightly crushed with a rolling-pin. Cream together the shortening, sirup, and sugar (or honey), add to this the well-beaten egg, then the flour and peanut mixture. Use a little milk if necessary to make a dough of such consistency that it can be rolled on the board. Turn onto a floured board, roll thin, and cut with a biscuit cutter. Place in shallow tins lightly greased and bake in a fairly hot oven until a delicate brown (about 10 minutes).

CORN MEAL COOKIES.

- | | |
|--------------------------------------|-----------------------------|
| 1½ cups sifted flour. | 3 tablespoons shortening |
| 1½ cups fine corn meal. | 1 egg. |
| 1 teaspoon salt. | 1 teaspoon vanilla extract. |
| 2 teaspoons baking powder. | Milk sufficient to mix. |
| ½ cup sirup with 3 tablespoons sugar | |
| (or ½ cup honey). | |

Follow directions given for soy-bean wafers, adding, however, the well-beaten egg to the creamed shortening, sirup and sugar, then the flavoring extract, and finally the flour mixture and milk if necessary. Roll thin, cut and bake until a delicate brown.

POTATO COOKIES.

- | | |
|----------------------------|---------------------------|
| 2 cups sifted flour. | 3 tablespoons shortening. |
| ½ teaspoon salt. | 1 egg well beaten. |
| 2 teaspoons baking powder. | 1 cup mashed potato. |
| ¾ cup brown sugar. | |

Cream together the shortening and sugar. To this add the well-beaten egg and the mashed potato (free from all lumps). Beat until smooth, then add the twice-sifted mixture of flour, salt, and baking powder. It will usually not be necessary to add any liquid. Mix until a dough is formed stiff enough

to roll. Place on floured board, roll until about $\frac{1}{8}$ inch thick, cut into rounds and place on greased baking sheet. Bake 15 minutes in a moderately hot oven or until a delicate brown. Bake more slowly than ordinary wheat-flour cookies.

OATMEAL DROP CAKES.

$\frac{3}{4}$ cup brown sugar or honey or 1 cup sirup.	2 cups rolled oats.
3 tablespoons shortening.	1 cup flour.
1 egg.	1 teaspoon salt.
2 teaspoons baking powder.	$\frac{3}{4}$ cup raisins or nuts.

Milk (about $\frac{3}{4}$ cup) enough to make soft dough. (Omit this if sirup or honey is used).

Cream together the shortening and sugar (or sirup) and add to it the beaten egg. Sift together the flour, salt, and baking powder. Mix with this the rolled oats and the seeded raisins or nuts cut fine. Add these dry ingredients to the egg mixture, with just enough milk, if necessary, to form a rather soft dough. Drop by teaspoonfuls onto a greased tin or baking sheet and bake about 15 minutes in a moderately hot oven.

GRAHAM DROP CAKES.

Follow directions for oatmeal drop cakes, using 3 cups of Graham flour in place of the mixture of rolled oats and white flour.

PASTRY.

Delicious, crisp pie crust and other plain pastry may be made by using at least 50 per cent of such substitutes as corn meal, corn flour, rice flour, sweet potato flour, rye flour, or Graham. The pastry is made in the same manner as usual, but the dough can not, as a rule, be handled well if it is rolled too thin. A little practice will, however, teach the housewife how she can best handle it.

CORN MEAL PIE CRUST..

(2 crusts.)

$\frac{3}{4}$ cup corn meal or corn flour.	$\frac{1}{2}$ teaspoon baking powder.
$\frac{3}{4}$ cup flour.	2 $\frac{1}{2}$ tablespoons shortening.
$\frac{1}{2}$ teaspoon salt.	Cold water to mix.

Sift together the meal, flour, salt, and baking powder. Cut in and blend the shortening with the dry materials. Mix to a stiff dough with a little cold water. Roll rather thin and use like other pastry. If a richer upper crust is desired, the latter, when rolled once, may be spread with additional shortening, folded over into thirds, and rolled again.

Any other fine meal or flour, such as rice, rye, sweet potato, etc., may be substituted for corn meal in the above recipe.

The above recipe may be used for crackers also. Roll thin, cut into desired shape, and bake until crisp and a delicate brown. Cheese straws may be made by rolling this same pastry thin, sprinkling over it 1 to 2 tablespoons grated cheese, folding into thirds, and rolling again. Cut into narrow strips and bake to a delicate brown.

GRAHAM OR WHOLE WHEAT PIE CRUST.

(2 crusts.)

1½ cups Graham flour.
 ½ teaspoon salt.
 ½ teaspoon baking powder.
 2½ tablespoons shortening.

Cold water to mix.
 (1 teaspoon of sweetening is an improvement.)

Sift together dry ingredients, blend shortening with same. Mix to dough of proper consistency with cold water in which has been dissolved the sirup or other sweetening. Roll, cut, and bake as usual.

GRAHAM SHORTCAKE.

2 cups Graham flour.
 1 teaspoon salt.
 3 teaspoons baking powder.

3 tablespoons shortening.
 1 or 2 tablespoons sweetening.
 Milk to mix.

Sift together the Graham flour, salt, and baking powder, returning the bran to this mixture. Blend with this the cold shortening as for biscuits. Mix with milk (in which has been dissolved the sirup) to form a soft dough. Roll on board in two sheets or spread in two tins. When baked spread with butter and cover with fruit which has been well sweetened.

SCORING BREAD.

The following score card applies to light bread made from white flour. When using wheat substitutes it must be remembered, first, that the volume of the loaf will not usually be as large as that made with white flour; second, that the color of the crumb will not usually be creamy—it will often be dark or distinctly colored; third, that the texture of the crumb may not be as good as that made with white flour alone.

In scoring breads made with wheat substitutes only those of the same kind should be scored together.

Bread score card.

	Points.
1. General appearance (form, smoothness of crust, uniformity and depth of color)	15
2. Size and lightness of loaf	10
3. Crust (crispness, tenderness)	10
4. Crumb—Color	5
5. Crumb—Texture (fineness and uniformity of grain)	10
6. Crumb—Elasticity (softness, pliability, springiness)	10
7. Flavor and odor	40
	100

It is very helpful, especially for a beginner in the art of bread making, to know what the characteristics of a good loaf of bread are.

Appearance.—First of all, bread should be attractive in appearance. This requires that it should be of good shape, evenly rounded

on top, with a smooth unbroken crust, having neither breaks nor bulges. It should be of a uniform golden brown color over the entire loaf.

Lightness.—It should be light, i. e., be relatively large for its weight.

Crust.—When the loaf is cut the crust should be found of even thickness over the entire loaf and should be crisp and tender rather than hard and tough.

Color of crumb.—The crumb should be of a pale creamy tint with a satiny luster or sheen as one looks across the loaf.

Texture.—The grain of the loaf should be fine and even, having many small cells, more or less uniform in size rather than fewer cells of larger size. A good bread flour, properly handled during the process of bread making, will usually yield cells oblong in shape rather than round, while the feel of it will be soft and almost velvety.

Elasticity.—The loaf should be elastic so that if pressed rather firmly between the hands it will spring back to its original shape when the pressure is removed. This elasticity is also evident if the cut portion of a loaf is pressed with the fingers and shows no impression after the pressure is removed.

Flavor.—Above everything, however, ranks flavor, for bread is made to be eaten, and no matter how attractive in appearance within or without the loaf which does not taste and smell good will never be a desirable one.



CURING HAY ON TRUCKS

A METHOD BY WHICH A GOOD QUALITY
OF HAY MAY BE CURED DURING
UNFAVORABLE WEATHER

H. B. McCLURE

Agriculturist



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Contribution from the Office of Farm Management

W. J. SPILLMAN, Chief

Washington, D. C.

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THE CURING truck is a device which supports hay during the curing process, protecting it from rain, and from moisture in the ground, and makes reasonably certain the production of a good quality of hay, even during unfavorable weather.

It requires no more man labor or horse labor for loading, unloading, or hauling than do the more familiar methods of curing.

This truck is the most economical and efficient device known for the successful making of hay in certain parts of the South, and can be recommended for large acreages, especially of alfalfa, in any section where the production of hay is a more or less hazardous undertaking on account of the prevalence of rainy or cloudy weather.

In counting the cost of this method, the items of repairs, interest, and depreciation may appear large, but any increase in these items is more than offset by the great gain in efficiency, considering the average loss of hay cured by ordinary methods in rainy weather. For instance, at the present price of Johnson grass hay, much grown in Southern States, the total cost of the trucks used in harvesting it by the method here described will be repaid by a saving over other methods of less than 1 per cent of a single crop.

Farmers living in humid regions and southern hay growers in particular will find it well worth while to investigate fully the advantages of the curing truck.

CURING HAY ON TRUCKS.

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THE SOUTHERN HAY INDUSTRY.

GROWING HAY for the market is a profitable business in certain sections of the South when a good quality of hay is produced. In Georgia, Alabama, and Mississippi, especially in the part known as the "Black Belt," growing hay for the market is becoming the leading enterprise on many farms. The principal kinds of hay grown for market are alfalfa, Johnson grass, and alfalfa and Johnson grass mixed hay.

The growing of hay for the market received a great impetus in these sections when the boll weevil made it impossible to grow cotton as extensively as formerly. Hay is well adapted as one of the crops to take the place of cotton in the sections infested by the boll weevil. It is easily grown, is in constant demand and, under certain conditions, is highly profitable. In this connection, however, care should be taken to avoid an overproduction of low-grade hay.

Johnson grass has been known in the South for many years and, until recently, has been regarded as one of the worst weed pests the farmer has had to contend with in the growing of cultivated crops, if not the very worst. Alfalfa grows well in the black soils of the South, but usually it can not be grown alone. Johnson grass will grow in spite of the usual efforts to get rid of it. Therefore those desiring to grow hay have stopped fighting Johnson grass and are now encouraging its growth. They can either grow it alone or with alfalfa; and the Johnson-alfalfa mixture makes an excellent hay, especially for horses. The hay-making season covers a period of several months, and from three to five cuttings are obtained per year. Growing hay in the South is accomplished without any very great difficulties.

The great drawback in producing hay is the difficulty in curing the hay during unfavorable weather. The hay-curing truck de-

scribed in this bulletin was designed to enable the grower to cure hay during rainy and cloudy spells of weather when all ordinary methods of curing in the field failed. The advisability and advantages of using the truck depend upon the possibility of avoiding by its use the greater part of the loss annually sustained by ordinary methods of curing.

LOSSES DUE TO UNFAVORABLE WEATHER.

Unfavorable weather during the haying season causes a loss to the grower in two ways. The first is due to the loss sustained by undue exposure of the hay to sun and rain. This includes the loss of color, which may be caused by either rain or sun and results in lowering of the selling price. The loss may go farther than simply loss of color. Hay in the cock may become moldy and unfit for feeding. Continued handling will cause a high percentage of leaf loss in alfalfa and other legume hay, which lowers its total nutrients. The second loss is due to the extra work involved when it becomes necessary to handle the hay to prevent spoiling. When hay in the cock becomes wet through with rain it is necessary to open the cocks and spread out the hay to prevent heating. Sometimes it is necessary to recock the hay after it has been spread out, and finish the curing in the cock. This extra labor increases the cost of making hay, and thereby decreases the profits.

HAYING WEATHER IN CENTRAL GEORGIA, ALABAMA, AND MISSISSIPPI.

The economy of using the curing truck depends upon the kind of weather prevailing during the haying season. Figure 1 shows the average monthly rainfall, number of days with 0.01 inch or more of rain, number of clear days, and number of cloudy or partly cloudy days for each month from May to October, for five stations, Augusta, Ga.; Montgomery, Ala.; Uniontown, Ala.; Demopolis, Ala.; and Agricultural College, Miss. The records have been kept so long (from 8 to 37 years) that the averages form a fair basis for knowing what kind of weather the hay grower will have to contend with while making hay.

The chart is arranged with the station having the greatest seasonal rainfall (Augusta, Ga.) at the top, and that having the least (Agricultural College, Miss.) at the bottom.

During the four months of May, June, July, and August, in which the greater portion of the yearly hay crop is harvested, 26 per cent of the days are rainy and 37 per cent clear in the Demopolis section, and 37 per cent are rainy and 33 per cent clear in the Augusta section. These two stations represent the maximum and minimum for percentage of rainy days at the five stations. For the combined

records during the four months 33 per cent of the days are found to be rainy, 24 per cent cloudy or partly cloudy, and 43 per cent clear.

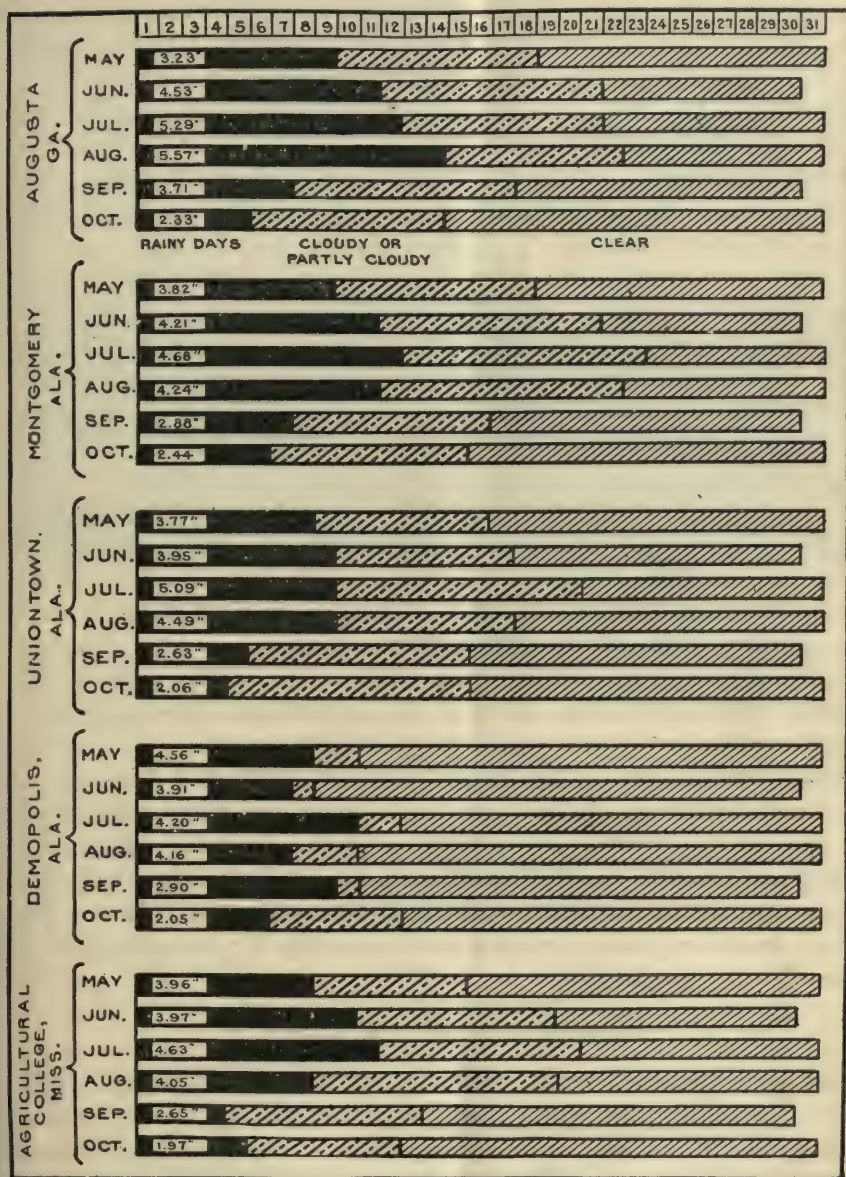


FIG. 1.—Relative numbers of rainy, cloudy, and clear days in the haying months at selected points in central Georgia, Alabama, and Mississippi. (Black, rainy; heavy shading, cloudy; light shading, clear.)

These data will materially assist the hay grower in determining whether or not to use the curing truck.

ORIGIN OF THE CURING TRUCK.

Unsatisfactory results obtained from curing hay by common field methods led Mr. J. E. Evans, of Monroe County, Miss., to experiment with different devices that would aid in securing a better quality of hay. Before the advent of the curing truck the best known method for that locality was to cure hay in well-made cocks containing from 100 to 600 pounds of cured hay.

During favorable weather, or even during transient unfavorable weather when only light showers occur, a fair quality of hay can be made by curing in the cock. If, however, the weather continues unfavorable for a period of a week or more and is marked by frequent heavy rains, the cocked hay will usually become wet through. The bottom of the cock will absorb moisture from the damp ground and spoil the hay. After the rains cease it is necessary to spread out the hay and sometimes recock, and when the hay is finally cured sufficiently to be baled or put into the barn or stack it will be of a very poor quality.

Hay caps can be used to advantage to keep the rain from entering the top of the cock, but even then the hay in the bottom will sometimes be damaged from the moisture in the ground unless some special device is used to prevent it. Various types of racks, frames, etc., holding from 100 to 2,000 pounds of cured hay have been designed and used more or less successfully when quality only is considered. Such devices usually require considerable extra-man labor in putting the hay on and getting it off the apparatus.

The device sought by Mr. Evans was one that would first permit the rapid handling of the partly-cured hay; one that would keep the hay off the ground and entirely protected from the rain while curing; and, lastly, one that would require but little labor and time in moving the hay after it was cured out ready for baling. The curing truck, as finally worked out, embodies all the essentials of these ideas. (See fig. 2.)

DESCRIPTION OF THE TRUCK.

The curing truck is quite similar to the ordinary hayrack. (See fig. 3.) It is 12 feet long and 7 feet wide and will hold from 1,500 to 2,000 pounds of cured hay, depending on how much the hay is cured when put on the truck. The back is supported by two 16 to 20 inch steel or iron wheels running on an axle placed about 4 feet from the rear end of an A-shaped frame.¹ When a loaded truck is not in motion, as when left in the field for the hay to cure or while it is waiting to be baled, the front end is supported by a 6 by 8 inch wooden block or "trigger" of sufficient length to hold the truck level.

¹ Wheels suitable for this purpose may be secured from mail-order houses.

This trigger is fastened between the two main frame timbers by a heavy bolt. enough play being left so that it swings easily by its



FIG. 2.—Right, loaded truck protected by a canvas cover. A well-loaded truck will contain about 1 ton of cured hay. Left, empty truck.

own weight. When the trigger is in use, it is held in a position just past the vertical, by coming into contact with the front coupling

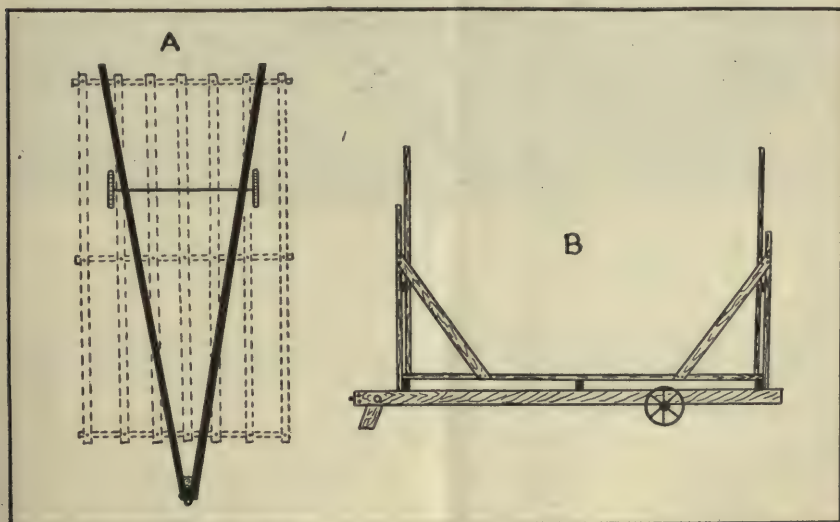


FIG. 3.—Main frame of truck (A), with rack indicated by dotted lines, and side view (B) showing trigger and position of wheels.

casting. When the trigger is not in use, the free end, pointing to the rear, drags lightly on the ground.

The standards at each end run to a point at the top, in which a notch is cut to receive a 2 by 4 inch ridgepole that supports the canvas and keeps it from lying flat on the hay, thus permitting the air to circulate freely at the top. The bottom is made up of seven 2 by 4 inch pieces, 12 feet long, evenly spaced to allow the air to enter freely. A coupling device is fastened to each end. The front coupling consists of a heavy, rigid ring, set in a cast-iron block, and the back one is shaped in the form of a hook. The couplings make it possible to haul a train of several empty trucks when returning them to the field. (See fig. 4.)



FIG. 4.—Empty truck, showing details of construction. A 2 by 4 ridge pole is held by the notches at top of standards. Note position of the "trigger" which holds the truck level.

The trucks are moved by means of a two-horse team and a two-wheel running gear similar to the front running gears of a low-wheeled wagon. A seat is provided for the driver, to be used when moving a truck some distance. (See figs. 5 and 6.) The front running gear is fastened to the truck by means of a long clevis pin. When the truck is being hauled, the weight of the front end rests on the front running gear. When the team starts, the forward movement causes the trigger to trip as it passes center and to drag on the ground, the weight of the load being thus shifted to the running gears. Upon reaching the destination the team is backed a step or

two, which causes the trigger to assume its upright position and again take its share of the weight of the load.



FIG. 5.—Front running gear used to haul trucks. It is attached easily by means of a long clevis pin. At left, Mr. Evans, who developed the method of curing hay described in this bulletin.

USING THE TRUCK.

In order to use the truck successfully, hay must be cured to a certain point before it is put on the truck. If not sufficiently cured,



FIG. 6.—Front gear coupled to empty truck. When the team starts forward the "trigger" trips and lower end drags on the ground.

there is danger that it will heat and spoil. Hay put on the truck when almost cured will not have as good a color as hay put on with

the proper degree of curing. Hay is in best condition to be put on the truck when it has cured enough to go into the cock or possibly just a trifle greener than when it ordinarily is cocked, as it is desirable to do the last third or fourth of the curing on the truck under a canvas cover, where it is protected from the sun and rain.

In order to have the hay in proper condition to be put on the trucks at a set time of day, it is necessary to arrange the time of mowing, tedding, raking, bunching, etc., so the hay will be ready when desired. Mr. Vester S. Mullins, of Noxubee County, Miss., uses the following method:

When the yield is light, say, about one-half of a ton per acre, the hay is mowed in the morning, raked in the afternoon, and put on the trucks in the evening, or the next morning, after the dew is off. When the yield is about 1 ton per acre, hay is mowed in the morning and tugged the next morning and raked into windrows before dinner. The hay is allowed to lie in the windrow only two hours before being put on the trucks.

BUNCHING HAY TO BE LOADED.

Hay may be taken directly from the windrow and loaded by hand onto the truck, but this is not a good practice, because it requires too much time to pitch hay up from the windrow and not leave any scatterings. It also obliges one man to spend much of his time in driving the team hauling the truck, when he might be better engaged in helping load.

The best practice is to bunch the hay after it has been raked into the windrow. This may be done with a sulky rake or a push rake. The sulky rake puts a much smaller amount of hay into a bunch than the push rake, and it is not as efficient an implement as the latter if more than two men are used to load the truck.

HANDLING AND LOADING THE TRUCKS.

Before the crew starts to work it is customary to bring several empty trucks to the field. Empty trucks are hauled to the field in trains of from 6 to 10 (fig. 7). Enough trucks should be brought to the field before loading is begun to last all day or at least half a day. This practice will save time, as the loading crew will not have to wait while trucks are being brought from a distance. If enough trucks are taken to the field in the morning to last until noon, the mower, rake, and push-rake teams may be used to haul trains of trucks to the field when returning to work after dinner.

The trains are left at different places in the field so as to be quickly accessible. Two trucks are used when loading starts. The front truck is loaded first and the second one is trailed behind to save time, since it does not add enough weight to make any material difference to the team. After the first truck is loaded the sides of the load are raked down carefully with pitchforks to cause the hay to

shed rain more easily, and a canvas is put on and tied at the four corners. This work is done while the team is being hitched to the second truck. The canvas is always put on, even if there is no indication of rain. When the second truck is nearly loaded; the driver unhitches his team and goes for two more empty trucks from the nearest train. While he is doing this, the pitchers, if necessary, carry a few forkfuls of hay from the nearest bunches to finish out the load. The loaded truck is left standing where the last hay is put on. There are two reasons for this practice; the more important one is that it is not advisable to haul loaded trucks very far over the ordinary hay field. The truck wheels are comparatively small and the average alfalfa and Johnson grass hay field is more or less rough, sometimes being very bumpy and uneven; and hauling shakes the hay and causes it to settle and become compact, preventing the cir-



FIG. 7.—A train of eight empty trucks being hauled to the field. The trucks are left at points in the field where they are quickly accessible.

ulation of the air, prolonging the curing process, and thereby increasing the danger of loss from heating. Also, if each truck were hauled to a central point it would be necessary to have a much larger number of teams, drivers, and front running gears in order to keep the loading crews busy all of the time. When the hay has all been loaded, the fact that the trucks are left scattered over the field nearly equidistant from each other indicates that the hay has been hauled no farther than absolutely necessary. (See fig. 8.)

SIZE OF LOADING CREWS.

Loading crews consist of two, three, or four men. A two-man crew can load about 14 trucks in 10 hours. Both men pitch onto the truck until the load is two-thirds on, when one man works on the truck, building and finishing off the top. When three men are used, one stays on the truck all of the time and builds the load and the other two pitch on the hay. (See figs. 9 and 10.) They will load about 20

trucks in 10 hours. A four-man crew may work in two ways; three men may be used to pitch on the hay if they are careful in placing the forkfuls on the truck in such a manner as to keep the hay level and



FIG. 8.—Trucks are left standing where the last hay is put on them. Hauling causes the hay to settle, which retards the curing, and causes loss of time.

fill out the corners. When this is done, one man only is needed on the load. The other method is to use two to pitch and two on the load. The two pitchers are then not concerned about where their forkfuls land on the load. All they need to do is to get as much hay



FIG. 9.—Loading the truck. When three men are used two pitch and one builds the load. One of the pitchers drives the team.

as possible onto the truck, leaving the placing of the hay to the two men building the load. A four-man crew should load, on an average, about 30 trucks in 10 hours. The average time required to load a truck by a two, three, and four man crew is 40, 30, and 20 minutes, respectively.

LOADING IS NOT EXTRA LABOR.

Some objection to the use of the trucks has been made on account of the necessity of loading them by hand. This objection is raised only by those who have not compared the amount of man labor required per ton when hay is cured in the cock with that required when the truck is used, for, as a matter of fact, less hand labor is needed when using the truck than when hay is cured in the cock.

Hay is raked with the sulky rake and bunched with the sulky rake or push rake in exactly the same manner whether cocked or put on the truck. If cured in the cock it is necessary to put the hay into carefully made cocks and each forkful must be placed exactly right to form a cock that will be symmetrical. When the truck is used it is not necessary to be so careful where each forkful is placed or just how much is taken up with the fork at a time. A man can handle more hay per hour or per day when pitching onto a truck than



FIG. 10.—Two men are sometimes used to load trucks. One man works on the truck after half of the load is on. The other man pitches and drives the team.

when building cocks, so that as far as labor requirements are concerned loading the truck has the advantage over cocking.

TIME REQUIRED TO CURE ON TRUCKS.

In good curing weather hay is in condition to be baled after curing three days on the truck. If the hay is a little green when put on the truck or the weather is unfavorable, it will take a week or possibly longer to cure out thoroughly. Hay may remain on the truck indefinitely, if well protected by a canvas cover, without injury from sun or rain when the truck is not needed for some time, as is often the case when a cutting is all finished. Some users of trucks put two canvases on each truck when they are to be left standing for a considerable time before being baled. A single canvas cover placed lengthwise covers the top well but does not protect as much of the sides of the load as do two canvases put on crosswise. It is sometimes

customary to place two canvases on each truck when there are prospects of a hard wind-driven rain. When hay is on the truck and protected in this manner, the hay grower's mind is at ease; and no matter how hard the storm may be or how long it may last, he is satisfied in the knowledge that his hay crop is safe and will bale up, having a good color and quality. Constant worry about the uncertainty of when and how much it will rain is the nightmare of the southern hay grower, and unfavorable weather is the greatest factor in preventing a larger acreage of hay in the South.

BALING.

ADVANTAGES OF USING THE TRUCK WHEN BALING.

Baling hay cured on trucks has several advantages over baling hay cured in the windrow, bunch, or cock. In the South a day's work is from sun to sun. Hay cured in the ordinary way can not be baled until the dew is gone, and the hayfield hands must be employed on other crops during the early part of the morning. Hay cured on trucks can be baled as early in the morning as desired. The canvas cover protects it from dew and a full day's baling can be done unless rain interferes.

Baling from the windrow, cock, or bunch is stopped by a light shower for some little time, and a heavy short shower will prevent baling for the remainder of the day. Showers stop baling from trucks only while rain is falling, since each truck is protected by a canvas and it is a matter of only a moment to throw one over a truck that is partly baled. When the rain is over the press crew can start to work again. These two advantages in using the truck are of considerable importance when farm labor is scarce, as it is at present in the South.

HAULING TRUCKS TO PRESS.

Truck-cured hay is usually baled in the field where it is grown. This is done for the reason that it is easier to move the press than to haul the hay long distances, as is the case where the hay is baled at the barn. One man and a good stout team are used to haul the loaded trucks to the press, and they can easily bring enough hay to keep the press going to full capacity, which is about 30 tons in 10 hours for a very efficient, fast-working crew. If the haul becomes so long that one man and team can not bring in the hay fast enough, the press is moved nearer to the hay. If the press is properly located when starting to bale up a field of hay, it need never be necessary to move it the first day, and sometimes not for two or three days, depending upon the yield. Moving the press should be done before the press crew begins work, at noon, or after the day's work is over, in order to avoid loss of time by the crew.

It is a good practice to have several loaded trucks hauled to the press before the press is started. (See fig. 11.) These should be brought from the distant parts of the field. The man and team hauling the trucks should always be at the press in time to place a truck in position to be unloaded just when it is needed. It is not necessary to hitch the team on the empty truck to haul it out of the way, for one man can easily do this by taking hold of the front end. As soon as a loaded truck is in position for unloading, the man hauling can start for another truck at a distance that will allow him to reach the press with his load by the time the last truck placed is unloaded.

STRIPPING THE HAY.

It will sometimes happen that the rain will wet in several inches of the sides of the hay below the canvas. This sometimes occurs



FIG. 11.—A "town" of loaded curing trucks. Loaded trucks are sometimes brought to a central point or "town" after the hay is thoroughly cured and is not to be baled for some time.

when one canvas is used, but is prevented when two are used. If the hay is not to be baled immediately, but little if any damage is done by the rain. If it is desired to bale it before the dampness is all out (it is understood that the hay was ready for baling when the rain occurred), the best thing to do is to "strip" the sides of the damp hay.

The stripping is done by hand in this manner: One man, detailed for this work, runs his hand under the hay and when he feels a damp place, pulls out the hay in each spot. The rain does not always run in along the whole side of a truck, but often just at places where the sides were not raked down carefully, but were left rough and did not shed water. After the damp hay has been removed from the spots it is spread out on the ground to dry and is afterwards baled. As a matter of fact a little damp hay might not make much difference in the feeding value of a 100-pound bale, but should a bale

show some bad hay on the outside, the buyer might be suspicious of the entire contents of the bale.

PRESS CREW.

The press crew is of the same size as when hay is baled from the cock, viz: One man to haul trucks, two to run wire and tie, one off-bearer, one feeder, two to three pitchers, and sometimes an engineer. A crew can bale about as much as when baling from the stack. The only time lost is while waiting for the empty truck to be pushed away and a loaded one brought up. It should not be necessary to lose over half a minute in doing this if the hauler is doing his full duty.

CARE OF BALED HAY.

To take care of the baled hay and prevent injury from rain or damp ground a large canvas should be kept handy where it can be thrown over the bales in case of a sudden rain. The safest plan is to haul the bales to the barn as soon as they come from the press.

ECONOMIC CONSIDERATIONS.

OTHER USES FOR THE TRUCK.

In addition to its primary use as a haying implement, the truck can be used to advantage in protecting bound grain from the rain until it is ready to be thrashed. It is also very handy in hauling corn to the silo, etc.

LIFE OF TRUCK.

The life of a truck depends, as with any other kind of farm machinery, on the care it receives. If a truck suffers hard or careless treatment, such as being overloaded and driven over very rough ground or into small open drainage ditches, it may not last very long. Such handling usually results in a number of trucks being badly injured or destroyed each year.

The truck is, however, a very simply constructed implement. It has no rapidly-moving or delicate parts to wear out, and it is not subject to deterioration by rust. It should last 10 years at least, or longer if a reasonable amount of care is exercised and no serious accident occurs to it. A good canvas will last about 10 years if it is well cared for and never put away when damp.

AMOUNT OF WORK PERFORMED.

Mixed alfalfa and Johnson grass hay is cut from three to five times a year. In an average year one can count on four crops. Assuming that it is necessary for hay to remain on a truck an average of 7 days or less and that it takes three weeks to harvest each cutting, each

truck will be used 12 times a year. Thus, in 10 years each truck will be used 120 times, and if one ton is put on at each time it will cure 120 tons during its life.

REPAIRS, INTEREST, AND DEPRECIATION.

The repairs on the truck are so small that this cost may be entirely disregarded. About the only upkeep cost is that of greasing the axles once a year. A truck and 12-ounce canvas, 9 by 14 feet in size, cost about \$20 in 1914. Interest at 8 per cent will amount to \$8.80, assuming that the truck is worn out at the end of 10 years, making interest and depreciation or replacement charges amount to \$28.80 during the life of the truck. If 120 tons are cured during the life of the truck, the total cost of using the truck will amount to 24 cents per ton of hay cured.

COST OF EQUIPMENT FOR 100 ACRES OF HAY.

The average yield of alfalfa and Johnson grass hay in the South is about three-fourths of a ton per cutting when the meadow is cut four times a year. One hundred acres will yield 75 tons per cutting. If a truck can be used three times per cutting 25 trucks will be required for 100 acres of hay. The 25 trucks and 25 canvases will cost \$500, or at the rate of \$5 per acre initial cost.

A cash outlay of \$5 per acre for every acre of hay land may, at first thought, seem to be prohibitive. However, when considering the cost of using the truck, 24 cents, or even double this amount, is a comparatively small amount to expend to insure the making of a ton of first-class hay. Some users of trucks claim and are positive that during a very unfavorable year a truck will pay for itself in one season. Twenty-four cents is about the cost of push-raking hay from the cock or windrow to the stack or press, and the writer has found that men who use the truck extensively are of the opinion that it is better to spend this amount and be reasonably sure of always getting a fair to choice grade of hay than not to use the truck and to have to stand heavy loss due to hay spoiled and lowered in quality by rain every year.

If hay is selling at \$20 per ton, assuming that the total cost of a truck is 24 cents per ton handled, the total cost of using a truck in harvesting a ton of hay would be repaid by the saving of but 24 pounds of hay.

LIMITATIONS OF THE TRUCK.

The writer wishes to caution those who may be led to adopt the method of curing described in this bulletin, that they must not expect all of the hay cured on the truck to be "choice." Artificial drying in kilns, heated either by means of steam or hot air, is the only method that will guarantee "choice" hay under all conditions.

However, curing on trucks is surpassed only by artificial curing, and is the best known method of curing in the field at a small cost of equipment. The reason why curing on trucks will not invariably make "choice" hay is that hay is often damaged more or less by rain before it is in condition to be put onto the truck. It may rain on the hay one or more times between the times the hay is cut and it is ready to be put on the truck.

If the rain comes before the newly mown hay has started to cure, the damage may be very slight. It is the intermittent wetting and drying out that causes the greatest damage to curing hay. When this happens, neither the curing truck nor the artificial drier can restore the hay to its former color and quality. However, when such hay is finally in condition to go on the truck there will be no further loss.

No matter what other method of field curing is used, the farmer must always run the risk of having his hay damaged or ruined before it can be protected from rain and sun. The point that the writer wishes to emphasize is that *the curing truck eliminates all danger of the hay spoiling either by loss of color or quality, after it has been put on the truck in proper condition and is properly protected by a good canvas cover.*

An up-to-date hay maker with a well organized and efficient haying crew, who takes every possible advantage of good weather, can use curing trucks to great advantage in certain parts of the South and Southeast.

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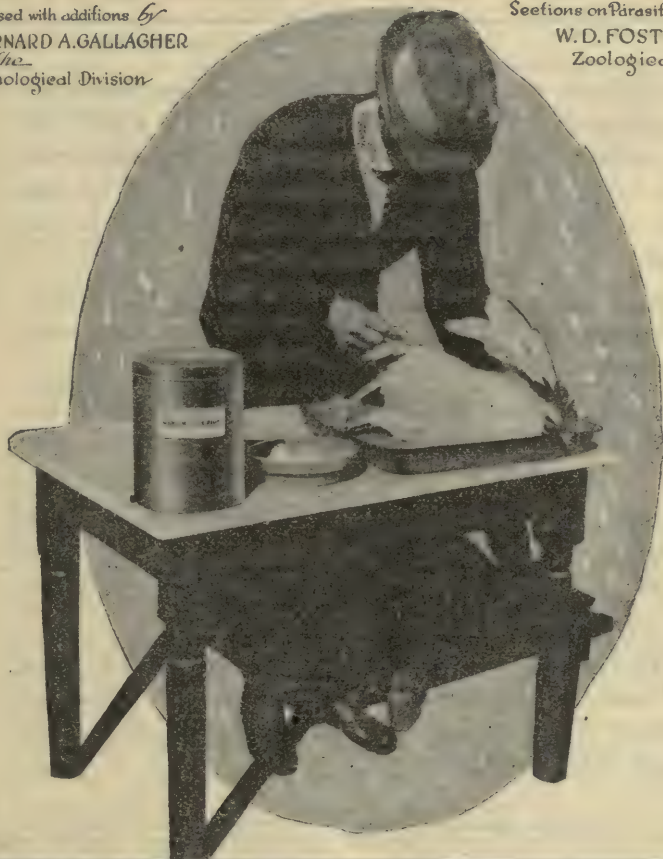
IMPORTANT POULTRY DISEASES

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FARMERS BULLETIN 957
UNITED STATES DEPARTMENT OF AGRICULTURE

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CHICKENS, turkeys, ducks, geese, and pigeons are susceptible to many diseases, some of which are highly infectious. Disease germs pass rapidly from bird to bird of the flock, and may be carried by one means or another to neighboring flocks, producing extensive outbreaks, or epizootics.

Certain diseases respond favorably to treatment. Others resist all efforts at treatment and cause very heavy losses.

Preventive measures properly applied offer the surest means of controlling diseases of domesticated birds.

It is necessary that the poultry owner be enlightened as to the characteristics of the more important diseases in order that he may intelligently use the most approved methods of combating them.

Sanitary and other measures which have been found successful in the control of poultry diseases may materially reduce the great annual losses in flocks if they are properly applied.

IMPORTANT POULTRY DISEASES.

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IMPORTANCE OF HEALTH IN POULTRY FLOCKS.

FOWLS are subject to a considerable number of diseases, some of which spread rapidly through the flock and cause a high mortality. They may also be infested by various kinds of parasites, some of which live on the surface of the body and others in the crop, stomach, or intestines. These parasites are injurious because they take a part of the nourishment which should be used by the bird to put on flesh or to produce eggs, and also because by their movements and their biting they cause irritation and inflammation of the parts which they attack.

The contagious diseases which are caused by animal and vegetable germs, and the weakness and loss of flesh caused by the larger parasites to which reference has just been made, are the most important conditions which the poultryman has to consider in the endeavor to keep his birds healthy. These germs and parasites should be kept out of the flock by suitable preventive measures, because disease may be avoided much more easily and cheaply than it can be cured. The aim in studying the diseases of poultry is, therefore, to learn how to prevent such diseases rather than how to cure them.

There are some cases in which medicines may be advantageously given or applied to fowls, but, as a rule, when a bird becomes sick it is better to kill it, because the cost of medicine and the value of the time required to carry out the treatment are greater than the value of the bird which is cured. Another reason for killing sick birds is that they may be affected by a contagious disease which before it

is recognized may spread to many other birds in the flock. A third reason for killing is the fact that a bird being sick indicates that it is more susceptible to disease than the other birds of the flock, and in order to establish a flock which is able to resist disease such susceptible birds must be eliminated.

The greater the number of birds kept upon any farm or plot of ground, and the more they are crowded together the greater is the danger from contagion and parasites, and the more important are the measures for excluding, eradicating, and preventing the development of these causes of disease.

HOW TO PREVENT DISEASE.

It is very important to start right and begin the flock with birds that are free from contagion and parasites, and to put such birds upon ground which is likewise free from these causes of disease.

The best way to accomplish this is to get eggs from a flock which has shown no indications of contagious disease for at least a year; avoid putting these eggs in any packing such as chaff, oats, or cut straw which may be musty or moldy; wipe the eggs with a cloth wet in 70 to 80 per cent alcohol, and hatch them in a new or thoroughly cleaned incubator. The young chicks should be free from parasites and injurious germs of all kinds, and to keep them in this condition they should be put into new or clean brooders and permitted to run only upon ground where poultry has not previously been kept or which has not been used for poultry for several years.

Sometimes these directions can not be followed in all respects. If all the available ground has been recently used for poultry, the fowls should be removed from that part which is to be used for the new flock, a good coating of freshly slaked lime should be applied to the entire surface of the ground, and a few days later it should be plowed. It may now be cultivated three or four times with intervals of a week and finally sowed with oats, rye, or other grain. In a few months the greater part of the germs will be destroyed; but it is best to leave the ground unoccupied by fowls until a winter has passed, as the freezing and thawing of fall and spring are more effective than either continued cold or warm weather.

If the eggs must be hatched under hens instead of in the incubator, the problem of starting a clean flock is much more difficult. Hens are liable to harbor parasitic worms in their intestines and to scatter the eggs of these worms with their manure wherever they go. They generally have lice and mites hidden in their feathers, which pass to the young chicks immediately after the latter are hatched; and they may be the carriers of disease germs even when they appear perfectly healthy. For these reasons the hens which are used for hatching should be selected from a flock that is known to have been

free from other diseases than those caused by accidents for at least a year, and the individual birds of which are lively, vigorous, free from lice and mites, and are producing a large number of eggs.

The hens selected for hatching should be well dusted with a good lice powder before they are given a setting of eggs; their nests should be perfectly clean and should be made with fresh, soft hay or straw; and there should be a box of road dust, or sifted hard-coal ashes, or similar substances, under cover, where they can dust themselves whenever they come from the nest. When the young chicks are taken from the nest they should be carefully examined for lice. These parasites usually accumulate under the throat and upon the top and back of the head. If any are found, rub a little sweet oil, pure lard, or vaseline with the finger over the parts where the lice are. This kills the lice by obstructing their breathing pores and does not harm the chicks.

By beginning in this manner a flock may be obtained which is practically free from disease germs and parasites, but in order to keep it in this condition the premises must be frequently cleaned and occasionally disinfected. There are a number of reasons for this. First, there are certain germs generally present in the intestines of healthy fowls that are scattered with the manure, and which, when they are permitted to accumulate and become very numerous, may cause outbreaks of disease; second, the germs of contagious diseases may be brought to the poultry yard by pigeons or other birds which fly from one poultry yard to another, or by mice or rats; third, it is seldom that ground is obtained for the poultry yard which is entirely free from infection with the eggs of parasitic worms and the spores of disease-producing microbes. To keep these germs and parasites from developing and increasing their numbers to a dangerous extent the houses should be kept clean, the drinking fountains and feed troughs should be washed every week with boiling water or other disinfectant, and, if any lice or mites are found on the birds or in their houses, the roosts and adjoining parts of the walls should be painted with a mixture of kerosene, 1 quart, and crude carbolic acid or crude cresol, 1 teacupful (1 gill). Or the house may be whitewashed with freshly slaked lime or sprayed with kerosene emulsion. The fowls should be dusted with lice powder.

DISINFECTANTS AND THEIR APPLICATION.

Good disinfectants destroy the germs of contagious diseases, the external parasites, such as lice and mites, and in some cases the eggs of parasitic worms. The eggs of some kinds of worms are so resistant that disinfectants other than heat have little effect upon them. The disinfectants should be thoroughly applied to the interior of

the houses, worked into all the cracks and crevices, spread over the ceiling and the floor, the roosts, dropping boards, and nest boxes. At the same time the feeding and drinking troughs should be disinfected by pouring boiling water into them and afterwards drying them in the sun. Disinfectants are most easily applied to the walls and ceilings with a spray pump or by using a brush. As it is difficult to keep them from coming into contact with the face and hands, the more harmless of these mixtures should generally be used. Ordinary limewash made from freshly slaked lime is excellent, and its properties are well known to all. In the case of an actual outbreak of virulent disease it is well to add to the limewash 6 ounces of crude carbolic acid to each gallon, to increase its activity as a disinfectant.

The kerosene emulsion, which is frequently used to destroy mites, may readily be converted into a disinfectant. To make the emulsion, shave half a pound of hard laundry soap into half a gallon of soft water and boil the mixture until all the soap is dissolved, then remove it to a safe distance from the fire and stir into it, at once, while still hot, 2 gallons of kerosene oil. This makes a thick, creamy emulsion, or stock mixture. When it is to be used for killing mites in the houses, 1 quart of this emulsion is mixed with 10 quarts of water. When it is to be used as a disinfectant, stir well, then add 1 pint crude carbolic acid or crude cresol, and again stir until all is well mixed.

The compound solution of cresol is one of the best disinfectants which may be purchased ready for use. It contains 50 per cent of cresol, and 1 pint of it added to 10 quarts of water makes a solution of the proper strength to apply to the houses or to spray over the ground. A 5 per cent solution of carbolic acid (1 pint carbolic acid to 10 quarts of water) is about equally efficacious. The choice between the two is a matter of convenience.

CONTAGIOUS CATARRH (ROUP).

The disease called "roup" by poultrymen is a contagious catarrh, closely resembling the more malignant forms of influenza in the larger animals and in man. It attacks principally the membranes lining the eye, the sacs below the eye (infraorbital sinuses), the nostrils, the larynx, and the trachea. It is attended with high fever and is very contagious. (Fig. 1.)

Causation.—Roup appears to be a strictly contagious disease; that is, one which arises only, so far as known, by contagion from other diseased birds. The nature of the microbe which constitutes the virus is not known. The contagion is generally brought into the poultry yard by infected birds. Sometimes these are birds which are purchased from other flocks in which the disease exists; some-

times they are birds of the home flock which have been in exhibitions and there exposed to sick fowls; and sometimes they are wild birds or pigeons which fly from one poultry yard to another.

The saliva and the discharge which escapes from the nostrils carry the contagion and soon contaminate the drinking water and feeding troughs so that all the fowls are infected. Even the flocks in adjoining yards are infected by the particles of mucus projected into the air when sneezing, or by the contagion carried on the feet of persons, animals, or small birds that pass from one yard to another.

Delicate birds are inclined to severe attacks and to recover slowly, and often a chronic condition persists for a long time. Birds so

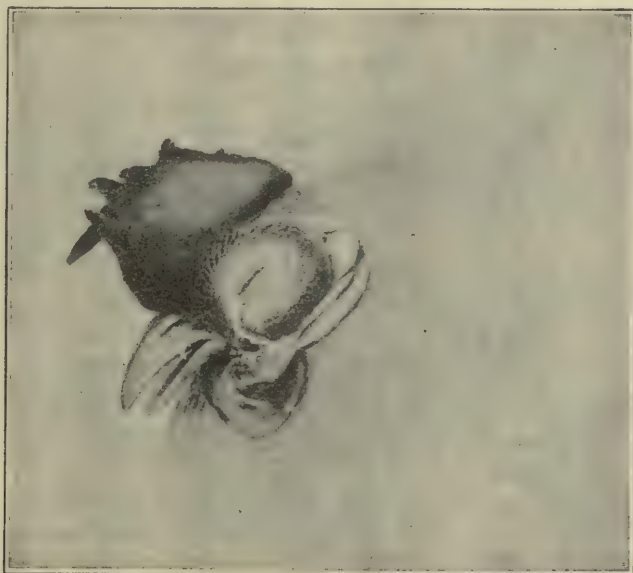


FIG. 1.—Head of fowl affected with contagious catarrh (roup), showing swelling of the eye.

affected may carry and spread the contagion for a year or more and become the cause of new outbreaks of the disease.

Symptoms.—The symptoms first seen are very similar to those of an ordinary cold, but there is more fever, dullness, and prostration. The discharge from the nasal opening is at first thin and watery, but in two or three days it becomes thick and obstructs the breathing. The inflammation, which begins in the nasal passages, soon extends to the eyes and to the spaces which exist immediately below the eyeballs (infraorbital sinuses). The eyelids are swollen, held closed much of the time, and may be glued together by the accumulated secretion. The birds sneeze and shake their heads in their efforts to free the air passages from the thick mucus. The appetite is diminished, and the

birds sit with their heads drawn in and their wings drooping, having a general appearance of depression and sickness.

When the inflammation reaches the spaces or sacs beneath the eyes it causes the formation of a secretion very similar to that of the nose, and as this becomes thick it collects, distends the walls of these spaces, and produces a warm and painful swelling, which is seen just below the eyes and may reach the size of a hickory nut. This swelling presses with much force on the eyeball, which is displaced and more or less deformed, and in extreme cases even the bones of the head may give way before it.

The closure of the eyes prevents the badly affected birds from finding food; the accumulation of mucus in the nostrils completely obstructs these passages, so that the beak must be kept open in order to breathe; the obstruction of the windpipe and the smaller air tubes causes loud breathing sounds and difficult respiration.

In the severe and advanced cases the birds sit in a somnolent or semiconscious condition, unable to see or to eat; their strength is rapidly exhausted, and many of them die within a week or 10 days. A part of the affected individuals recover, but others continue weak and have a chronic form of the disease for months, during which time they continue to disseminate the contagion.

This disease is distinguished from diphtheria by the absence of the thick, tough, and very adherent newly formed membranes (false membranes) in the nostrils, mouth, and throat which are characteristic of the latter. There may sometimes be a deposit of yellowish material on the walls of the mouth and throat, but it is easily broken up and removed.

Treatment.—The medical treatment of this disease may be very successful if properly applied. The sick birds should be removed from the flock and put into a warm, dry, and well-ventilated room which is free from drafts. The affected mucous membranes should then be treated by applying antiseptic and healing mixtures. The best method is to use a good spraying apparatus, but, lacking this, a small syringe, an oil can, or even a medicine dropper can be made to answer the purpose, or the bird's head may be plunged into a basin or bowl of the mixture and held there a few seconds, but not long enough to cause suffocation.

The remedies most suitable for such treatment are: Boric acid, 1 ounce; water, 1 quart. Or, permanganate of potash, 1 dram; water, 1 pint. Or, boric acid, $1\frac{1}{4}$ ounces; borate of soda, $\frac{1}{2}$ ounce; water, 1 quart. Or, peroxid of hydrogen, 1 ounce; water, 3 ounces.

Where the inflammation has progressed to the eye, excellent results have followed the use of argyrol. One or two drops of a 15 per cent solution is introduced between the eyelids twice daily for a period of several days.

cause them differ in some of their characteristics. The symptoms and the changes which are seen after death are so nearly identical that it is only by studying the bacteria that any one of these diseases can be distinguished from the others. The treatment applicable to one is equally applicable to the others. For the practical purpose of combating them in the poultry yard we may therefore group these diseases together.

Causation.—Certain germs (bacteria) like *Bacillus coli*, which are nearly always found in the intestines of healthy fowls, have more or less power to produce disease, but the sound, healthy fowl is able to resist them under favorable conditions. If these germs are inoculated into canary birds, they produce a fatal disease, because the canary does not have the power to resist them. If inoculated from one canary to another three or four times, these germs have their disease-producing powers so increased that they are able to kill adult fowls. When the resisting powers of fowls are diminished by exposure to cold, hunger, thirst, and exhaustion, as occurs during long shipments by rail, these germs may also cause disease in the fowls. In some countries the sickness which develops from these conditions is called "the transportation disease."

It sometimes happens that these diseases develop in poultry yards which are not kept clean, possibly because of the large numbers of germs which are taken into the bodies of the birds. When they begin growing in the tissues of fowls they soon increase their virulence, and the disease which they cause may rapidly spread from fowl to fowl until the greater part of the birds are dead.

The choleralike diseases may, therefore, either develop in the poultry yard from insanitary conditions, or they may be introduced by contagion carried by new birds which are added to the flock, by birds which have been to exhibitions, by wild birds which fly from one poultry yard to another, or by various animals, such as dogs, cats, rats, etc. Birds which recover from a disease may sometimes carry the germs and disseminate the contagion for six months or a year after they are apparently well.

Symptoms.—The manifestations of these diseases are much like those of cholera and for practical purposes need not be given separately. The choleralike diseases are differentiated from true cholera by their slower spread and lessened mortality.

Treatment.—Treatment and prevention follow the same lines advised for cholera.

FWL TYPHOID.

Fowl typhoid is a septicemia of fowls characterized by a drowsy, anemic appearance, extensive blood changes, and alterations in the

abdominal organs. It may at times occur in extensive epizootics. It bears no relation to typhoid of man.

Causation.—The causative agent, *Bacterium sanguinarium*, is a small rod-shaped organism which closely resembles *Bacterium pullorum*, the organism of bacillary white diarrhea of chicks. It is introduced on the premises through the agency of carriers, such as infected fowls, materials from infected poultry plants, by free flying birds, or on the feet of men or animals which have been on infected premises. The disease usually spreads rapidly in a flock, but is not so destructive as acute fowl cholera.

Symptoms.—There is drowsiness followed by prostration, which may last for several hours to one or two days. The membranes of the head, comb, and wattles are paler than normal; the temperature is elevated 3° or 4°. The blood is thin, pale red in color, and does not clot readily. The red blood corpuscles are greatly decreased in number, while the number of white blood corpuscles is greatly increased. Internally the liver is much enlarged, dark colored, and covered with minute necrotic spots. The spleen may also be enlarged and softened. The serous membranes are pale. Occasionally the mucous membrane of the intestine is slightly congested. In the fatal cases death occurs in 3 to 15 days after exposure.

Treatment.—The treatment advised for cholera applies also to fowl typhoid.

WHITE DIARRHEA OF CHICKS.

White diarrhea is a condition which has as its most prominent symptom more or less profuse diarrhea, the droppings consisting almost entirely of mucus from the intestinal tube and the white secretion of the kidneys. The diarrhea results from irritation of the intestines and the increased secretion of mucus, while the large quantity of white material secreted by the kidneys is due to fever and the rapid breaking down of the elements of the tissues. This condition is most frequently seen with incubator chicks, but is also common with those which are hatched under hens. (Fig. 4.)

Causation.—It has been found by investigation that the white diarrhea of young chicks is caused by at least four different kinds of infection, and each of them needs to be studied separately. All these microbes also infect adult fowls and are generally communicated directly or indirectly from these to the chicks.

The most common cause of the disease is an organism called *Bacterium pullorum*. This often infects hens and also the eggs which they lay. Such eggs produce chicks which have the germs of the disease within them when they are hatched, and these chicks show symptoms within the first few days of their lives. The contagion may also be communicated from chick to chick by means of the

microbes scattered with the droppings, which contaminate the food and drink and cause the appearance of the symptoms when the birds are from one to two weeks old. The chicks are most susceptible to infection during the first 24 hours of their lives, are more resistant during the second and third days, and are practically insusceptible after the fourth day. Those that sicken later must have taken the microbes into their bodies before they reached that age. Incubators and brooders, as well as coops, become infected and preserve the contagion indefinitely. Adult fowls are quite resistant to this microbe and usually do not show any symptoms, even when they are laying infected eggs.

The cholera bacillus may also be carried by laying hens and infect the egg before it is laid. The young chicks hatched from such eggs



FIG. 4.—Chicks affected with white diarrhea.

soon show symptoms of disease and communicate the contagion to others at all ages.

The coccidia which cause a chronic disease in adult fowls may also infect the eggs and cause disease with similar symptoms in the chicks.

The aspergillus fungus is the fourth cause of white diarrhea. It occasionally is included in the egg when it is laid, but it may also penetrate the shell when eggs are packed in moldy chaff, straw, or grain, or allowed to get damp.

All these germs may also be carried on the outside of the shell and may infect nest boxes, incubators, brooders, and yards where diseased chickens have been.

Symptoms.—The symptoms of white diarrhea are seen in young chicks which are from a day or two to three or four weeks old. In the most acute form they may die suddenly after having shown but slight symptoms for a short time. Generally, however, there is first observed a disposition to huddle together and to remain under the hover or under the hen more than young chicks should. Very soon

they appear listless, stupid, sleepy, and indifferent to what is going on about them. They stand in one position or sit still with the eyes closed, and the few efforts which they make to pick up food appear mechanical and unsuccessful. Their plumage loses its luster, the wings droop or project slightly from the body, and the characteristic diarrhea soon appears. The droppings which are voided may be white and creamy, mucilaginous and glairy, or they may be mixed with a brownish material. In acute coccidial white diarrhea the droppings are frequently bloody. Often the sticky excrement adheres to the downy feathers about the vent, dries, and continues to accumulate until it completely covers and plugs the opening. This condition, known as "pasting up behind," will, unless soon relieved, bring about the early death of the chick.

Many of the diseased chicks chirp or peep almost constantly, and when attempting to void the excrement they may give utterance to a shrill cry, as if the effort brought on paroxysms of pain. As death approaches, the breathing becomes labored and the abdomen heaves with each breath.

Often the disease is of a more chronic type and has a longer course. The young birds with diarrhea gradually waste away, becoming weaker and more emaciated until their legs are scarcely able to support their bodies. They try to brace themselves by standing with the legs apart, or they rest against a wall or other object for support. Many of them have the peculiar form of body called "short backed," which results from the distention of the abdomen and its projection backward, which makes the back appear too short for the body. Toward the last the strength is completely exhausted, and the chick sits constantly or lies on the side with outstretched wings until it dies. The most prominent and characteristic symptoms in nearly all cases are the white diarrheal discharges and the rapid wasting away of the affected birds. The losses vary from 50 to 80 per cent of the chicks hatched. Sometimes it is impossible to raise any of them.

Post-mortem examination reveals an unabsorbed yolk in the majority of cases. In white diarrhea caused by *Bacterium pullorum* the liver may have an ocher color and areas of congestion. The lungs may show small necrotic spots. In coccidial white diarrhea the cæca or blind pouches of the intestine are usually distended with necrotic or bloody material. In aspergillar white diarrhea the lungs and air sacs are the seat of moldy growths.

Treatment.—The medical treatment of affected chicks is impracticable, except in the coccidial form, as it is too expensive and has very little effect on the course of the disease. The birds may be given sour milk or buttermilk to drink. One-third teaspoonful of powdered catechu added to the gallon of drinking water is very effective in the coccidial form of white diarrhea.

Prevention.—The preventive measures should begin with the eggs used for hatching. If these are purchased, they should be accepted only from flocks known to be healthy and the eggs of which give rise to healthy chicks. If this assurance can not be obtained, it is better to produce the eggs needed for hatching on the home farm and from hens that are known to be free from infection.

Having obtained the eggs, they should be kept until ready for incubation in a dry, moderately cool place, so spread out that the air can circulate over them and carry away the moisture which they exhale. They should not be placed in hay, straw, chaff, or other substance liable to become musty or moldy. Before putting them into the incubator or under the hen they should be wiped with a cloth wet in grain alcohol of 70 to 80 per cent strength to remove any germs that might be on the surface of the shell. The hens used for hatching should be free from all infection, and the incubator should be thoroughly cleaned. If there have been any sick chicks in it, it should be disinfected by washing with compound solution of cresol (5 per cent solution). The same precautions should be adopted in regard to the brooder.

If the hatching is done by a hen the brood should be put upon fresh ground, and any chicks which sicken should be immediately removed and isolated or killed. By removing frequently to fresh ground or by frequent disinfection the disease may sometimes be limited to a few individuals.

If the hatching is done in an incubator and there is reason to suspect that the disease may develop, it is well to divide the trays and the brooders by light partitions so that not more than four or six chicks will be in one lot and exposed to one another. If white diarrhea appears in any of these lots, such lots may be removed and the places which they have occupied may be disinfected. After four or five days the partitions may be removed and the healthy lots of chicks put together. In this way the greater part of the chicks are protected against the most common form of the disease.

BACTERIUM PULLORUM INFECTION OF FOWLS.

The *Bacterium pullorum* also causes a form of disease which is generally confined to the ovary. Except in the case of comparatively rare acute outbreaks, no external symptoms are apparent. This infection is widespread in the United States and is responsible for enormous losses through its spread by means of the egg to baby chicks, causing white diarrhea.

Causation.—Chicks which recover from bacillary white diarrhea frequently retain the causative organism, *Bacterium pullorum*, in their systems, where it later localizes in the active ovary. The disease

may be contracted also by feeding with fowls that harbor the organism or by eating infected eggs. In some cases 50 to 70 per cent of a flock of hens may be found affected.

Symptoms.—In acute outbreaks or in experimental infection the bird becomes droopy, the feathers ruffled, the comb and wattles pale, and the head drawn back. There is loss of appetite, and diarrhea is often in evidence. Death follows in from one to several days.

In the ordinary form of the disease no external symptoms are observed. Internally the ovary presents a characteristic appearance. The partially or wholly developed ova (eggs) are angular in outline, shrunken, hard, and discolored to a dark-brown or greenish color.



FIG. 5.—Normal ovary of fowl (left) and ovary affected with *Bacterium pullorum* (right). (After Rettger.)

(See fig. 5.) At times ova containing dark fluid are present. The bacterium is readily recovered from the ovary by means of artificial culture media.

The presence of the disease in a flock may be detected by post-mortem examination and by laboratory methods.

Treatment.—The nature of the affection renders treatment futile. Flocks which harbor the infection should not be used for breeding purposes. The cycle of infection established by the hen, the egg, the recovered baby chick, and pullet indicates that it is not advisable to save for breeders any chicks which have been exposed to an outbreak of white diarrhea.

COCCIDIOSIS.

Coccidiosis is a disease produced by parasitic organisms of microscopic size called "coccidia." These parasites are widely distributed in nature and frequently attack birds and the smaller mammals, such as rabbits, rats, and mice. They are very destructive to young birds.

Causation.—Many different species of birds are attacked by coccidiosis. Pigeons are particularly liable to the disease, and are frequently responsible for outbreaks in poultry yards. The transmission of the contagion from diseased to healthy birds occurs by contamination of the food, water, gravel, and other substances taken into the digestive organs. The coccidia multiply with great rapidity in the intestines of diseased birds, and enormous numbers are discharged with the droppings and are carried on the birds' feet to the feed troughs and drinking fountains unless these are well protected and of such form that they can not be reached by the feet. Under any circumstances they are spread over the floor of the houses and the surface of the runs, and many will be picked up with gravel, grain, and other substances. The germs are found in the part of the small intestines nearest to the gizzard, where they cause inflammation with redness and thickening of the intestinal wall. They are also found in the cæca (two blind pouches of the intestine), which are frequently thickened and distended with a whitish, yellowish, or greenish-yellow, pasty mass. After two or three weeks the disease may extend to the liver and lungs, where it is recognized by whitish or yellowish spots or by large, cheesy nodules. Geese are attacked by another species which causes nodules in the kidneys.

Symptoms.—Adult fowls have considerable powers of resistance to this parasite, and the disease with them is more frequently seen in a chronic form. The symptoms are dullness, weakness, sleepiness, diarrhea, and loss of weight, although the birds retain their appetites for a considerable time. In many cases the only symptoms are diarrhea, with loss of weight, and after a time apparent recovery, though the germs continue to multiply in the intestine and to be spread with the droppings for several months afterwards. Fowls affected in this manner may die suddenly without previously showing any serious symptoms. Young chicks frequently void bloody droppings, and the bowel contents are bloody.

Pigeons are affected with a more acute type of this disease in which the symptoms appear only a short time before death. Generally, however, they are dull and sleepy for a day or two, and sometimes they have a chronic form, characterized by diarrhea and loss of weight.

Geese with coccidiosis of the kidneys lose flesh rapidly, without apparent cause, and become very weak and almost unable to walk.

They remain quiet most of the time, with the belly resting upon the ground. Some of them lie on their backs with their feet widely separated, and if placed upon their feet take a few steps, fall, and resume the former position. In all such cases the birds lose their appetites and become progressively weaker until they die.

Treatment.—The most successful treatment has been to put one-third teaspoonful of catechu in each gallon of the water given the birds to drink. Permanganate of potash, one-fourth of an ounce to the gallon of drinking water, is quite effective. They should also be given an occasional dose of calomel ($\frac{3}{4}$ to 1 grain) or castor oil (2 to 3 teaspoonfuls), mixed with 10 drops of oil of turpentine for each adult.

Prevention.—As the coccidia are brought on the premises with birds or with eggs for hatching obtained from infected flocks, or by pigeons flying from place to place, the necessary precautions should be observed to guard against such channels of infection. Fowls and eggs should be obtained only from flocks known to be healthy, and pigeons should be excluded from the poultry yard.

This form of contagion is very difficult to destroy, and the most active disinfectants should be used. A mixture containing 10 per cent of the compound solution of cresol is not too strong. The bodies of the birds which die should be burned.

ASPERGILLOSIS (BROODER PNEUMONIA).

One of the common molds, called *Aspergillus fumigatus*, sometimes attacks the respiratory or digestive organs of fowls, especially young chicks, producing either whitish or yellowish tuberclelike nodules in the tissues or large, flat elevations of a dirty yellow or greenish coloration on the surface of the mucous membranes. Each of the nodules contains a growth of the mold at its center, inclosed and imprisoned by a wall of animal cells. The flat elevations, however, represent the free growth of the mold on the surface of the mucous membrane, having very much the appearance which it presents when growing outside of the body on dead organic matter. The greenish color of the diseased area is due to the greenish filaments of the mold or fungus growing upon its surface. The filaments are not all on the surface, however, but penetrate deeply into the tissues, causing inflammation and swelling, which obstruct the respiration, and at the same time they apparently produce a poison which causes general depression and fever. The changes caused by the development of this fungus are most frequently seen in the mouth, the trachea, the bronchial tubes, the lungs, and the air sacs. but they may occur also in the alimentary canal.

Causation.—The *Aspergillus fumigatus* is a very common fungus of great vegetative and resisting powers which is found everywhere

growing upon dead organic matter of the most varied kinds. Its development is favored by warmth and moisture, and its spores are often found in enormous numbers in musty or moldy hay, straw, or grain. The mucus on the surface of the membranes, the serum beneath them, and the temperature of the bird's body are all favorable to its growth, while in addition it has the power to resist the efforts of the animal tissues to overcome and dislodge it. Having such characteristics, this fungus is one to be excluded, so far as possible, from the habitations of poultry, for otherwise it may cause severe and fatal disease.

The spores of *aspergillus* are most frequently introduced with moldy hay, straw, or chaff that are given to the fowls to scratch in. Often the fungus grows on accumulations of manure, old leather, and similar substances when they are sufficiently moist, and produces spores in enormous numbers. The filaments of the fungus are capable of passing through the eggshell, and it is believed that some outbreaks in brooder chicks may be due to infected eggs which have been exposed to moldy material. Not all birds are susceptible to its attacks, and it seems to be the delicate breeds and the weak individuals that are most frequently its victims.

Symptoms.—This disease may be limited to a single bird, or it may affect a large number. When the air tubes or lungs are attacked, the first symptoms are a slight catarrh with accelerated breathing. Soon the swellings obstruct the passage of air, and there is a rattling or croupy sound, heard chiefly during expiration. The affected birds mope, separate themselves from the remainder of the flock, or remain in a sitting posture; if made to move, it is seen that they are weak and scarcely able to walk, and if they try to run they soon fall from exhaustion. The difficulty of breathing increases rapidly; they gasp for breath, and make movements of the head and neck, as if choking; there is fever, diarrhea, drooping wings, great depression, a tendency to sleep, and finally suffocation and death.

When the disease is limited to the large air sacs the only symptoms are progressive loss of flesh and weakness. If the small air sacs of the bones are involved, which rarely occurs, there may be lameness, with swollen and inflamed joints. After death the yellowish nodules are sometimes found in the liver and kidneys as well as in the other organs which have been mentioned. The symptoms in brooder chicks are similar to those of white diarrhea.

Treatment.—This disease is a most difficult one to cure, but sometimes affected birds may be saved by applying flowers of sulphur or tincture of iodine to the diseased patches seen in the mouth and throat, and causing the birds to inhale the vapor of tar water or turpentine. Tar water is obtained by stirring two tablespoonfuls of wood tar in a quart of warm water and letting the mixture stand

for a few hours. Then the birds are taken into a closed room, where the tar water is poured, a small quantity at a time, on a hot brick or stone until the atmosphere of the room is well charged with the vapor.

Prevention.—The disease is prevented by giving only clean and bright straw or chaff for the fowls to scratch in, by keeping the houses and yards clean, and using grain and meal for feed which are sound and entirely free from mold. The sick birds should be removed from the flock, and the bodies of those which die should be burned or buried. The fungus sometimes spreads from bird to bird; consequently the isolation of the sick and the disinfection of the houses should not be neglected. Incubators and brooders should be cleaned and disinfected before use.

TUBERCULOSIS.

Tuberculosis of fowls is a chronic contagious disease, characterized by the development of nodules called tubercles in various organs of the body, but most frequently in the liver, spleen, and intestines. The disease is caused by a bacillus which differs somewhat in its manner of growth in artificial cultures from the bacilli which cause tuberculosis of people and of cattle. The tuberculosis of fowls is readily communicated to most species of birds and to several species of mammals, but it is almost impossible to communicate the tuberculosis of man and of cattle to fowls. Parrots and the smaller cage birds are very susceptible to human tuberculosis, however, and are often affected by it.

Causation.—Tuberculosis is generally brought into the poultry yard with fowls that are purchased from infected flocks or with the eggs of diseased birds that are obtained for hatching. If the disease exists in neighboring flocks the contagion may be carried by small birds or animals passing from one yard to another. A peculiarity of tuberculosis of birds is that the liver and intestines are nearly always very severely affected, and that as a consequence the bacilli are very numerous in the intestinal contents and are scattered with the droppings everywhere that the fowls go. The introduction of a single diseased bird may, therefore, cause the infection of the greater part of the flock in a few weeks. In the same way, when wild birds contract the disease the bacilli are carried and deposited in all the yards which they visit. (Fig. 6.)

The eggs of diseased birds frequently contain the bacilli, as has been proved by the inoculation of material from such eggs into susceptible experimental animals. The young chicks hatched from such infected eggs are diseased when they leave the shell and, of course, soon infect the poultry with which they run. Moreover, since the sterile incubated eggs are often fed to chickens, it is clear that even

the eggs which do not hatch may introduce the contagion unless they are cooked before feeding.

Pigs, cats, rats, and mice are especially liable to be infected with fowl tuberculosis from eating the carcasses of birds which have died, and these animals serve to keep up the contagion and may communicate it to other fowls. Even calves and colts are sometimes found suffering from this form of tuberculosis.

Symptoms.—Symptoms are generally not observed in the internal tuberculosis of fowls until the disease has reached an advanced stage of development. They begin with gradual loss of weight, wasting of the muscles, paleness of the comb, and, toward the end, dullness, sleepiness, and diarrhea. Very often there is at the same time a

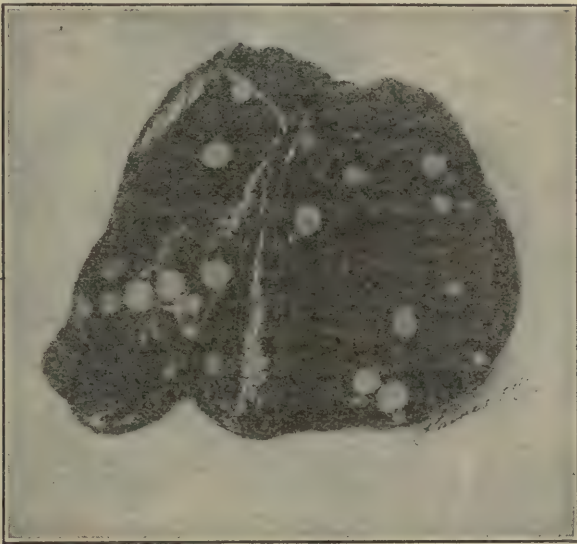


FIG. 6.—Liver of pheasant, showing lesions of tuberculosis.

tuberculous inflammation of the joints and of the sheaths of tendons which is revealed by lameness, swelling of the joints and legs, and sometimes by the formation of hard external tumors of considerable size. Occasionally the skin over the swollen joints breaks, the interior of the joint is ulcerated, and a small quantity of pus containing large numbers of tubercle bacilli is discharged. Swellings and bony enlargements of the joints with fowls are invariably suspicious, and their nature should always be investigated by killing the bird and examining the liver, spleen, and intestines to determine whether these have any whitish or yellowish spots on their surface which, when cut into, prove to be tuberculous masses.

Treatment.—There is no treatment that will cure fowls which have been attacked with tuberculosis. When the disease is discovered the

effort should be to eradicate it at once by killing off the whole flock and thoroughly disinfecting all the houses and runs.

As the great majority of the birds will probably be more or less affected, the chances are that any which are saved will have diseased livers and intestines, from which the bacilli will escape and keep up the infection of the flock and the runs. The danger of this is so great that no attempt should be made to keep any of the fowls that have been exposed to the contagion, no matter how valuable they may be. The bodies of the birds that have died or are killed, as well as all the accumulated manure, sweepings, and scrapings of the poultry houses, should be completely destroyed by fire.

So far as known there is no danger of communicating the disease to man by eating the cooked flesh of tuberculous fowls. In most cases, however, the diseased birds are so emaciated and their general health so affected that their flesh is not fit for human consumption. It is better in all cases to burn the carcasses of the birds in which tuberculous nodules are found, and thus avoid all danger of the disease being communicated to either man or animals.

BLACKHEAD (ENTEROHEPATITIS).

Enterohepatitis or blackhead is a disease of the intestine and liver which is most frequent in and most injurious to turkeys, but which according to some writers also attacks common fowls. In the course of the disease the head often becomes dark colored or nearly black, and for that reason it is popularly known as "blackhead," although it is only the internal organs that are directly affected by the disease. Blackhead is widely disseminated and in some localities has made the production of turkeys nearly impossible.

Causation.—The cause of blackhead is not definitely known. Three theories have been advanced in explanation of it: First, that it is caused by a parasitic protozoan known as *Amœba meleagridis*. According to this theory the amœba leaves the body of the sick bird with the excrement and infects other birds by entering the digestive organs with the food and drink. Second, that the microscopic elements which are always found in the diseased livers and cæca¹ of turkeys infected with blackhead are not amœbæ, but forms of certain other protozoan organisms known as flagellates. These flagellates occur in practically all turkeys, in the intestinal tract. Under ordinary conditions they are present in small numbers and cause no apparent trouble. In the presence, however, of unfavorable circumstances such as are liable to arise when turkeys are kept under the artificial conditions of domestication, digestive disturbances associated with diarrhea may occur, and in this case the flagellates multi-

¹ The cæca are two blind pouches or lateral extensions in the intestine.

ply rapidly and become very numerous. Many of them penetrate into the lining of the cæca and into the underlying tissues, and from there they may also be carried by the blood stream to the liver, where they establish new centers of disease. The third theory is much the same as the second but lays no stress upon the association of the disease with parasitic organisms. According to this theory the cause of blackhead is closely associated with the fact that the turkey is a species which has not become well adapted to the artificial conditions of domestication and that losses can best be avoided by handling turkeys with due regard to this fact. It is particularly important

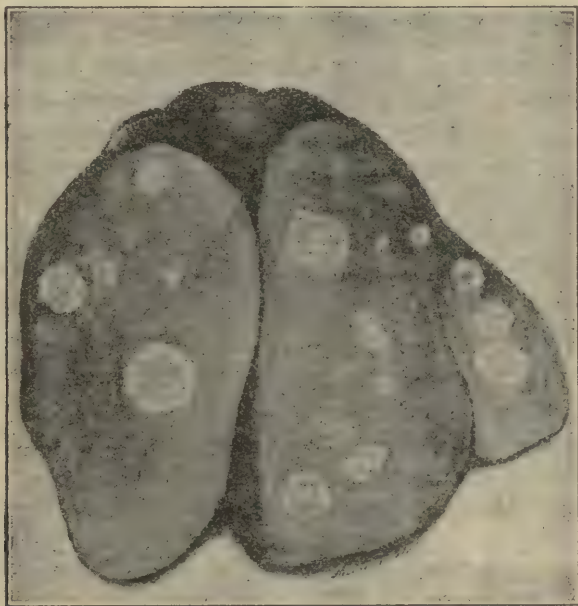


FIG. 7.—Enterohepatitis (blackhead). Liver of turkey. showing necrotic areas.

that care be taken in selecting strong, healthy stock, feeding properly, and protecting the young birds from infestation with lice and mites. The regular feeding of sour milk or buttermilk is believed by some writers to help in preventing the occurrence of blackhead.

Symptoms.—The symptoms of blackhead are most frequently seen in young turkeys, commonly called "poults," which are from 2 weeks to 3 or 4 months old. In the more acute cases the turkeys usually die in about two or three weeks, but generally the progress of the disease is slower and they live a longer time.

The affected birds at first appear less lively than usual, are not so active in searching for food, and when fed show a diminished appetite. Diarrhea is a nearly constant symptom, naturally associated with the inflammation of the cæca. As the disease progresses

there is more dullness and weakness, the wings and tail droop, and there is often the peculiar discoloration of the head, which led to the disease being called "blackhead." There is increasing prostration and loss of weight; the affected birds, instead of following their companions, stand about in a listless manner, indisposed to move, and paying little attention to what occurs about them.

The greater part of the affected poults die within 3 or 4 months after hatching, but with some the disease takes a more chronic form and does not cause death for a year or more. Nearly all die sooner or later from the effects of the disease, but in a small proportion of the cases there is healing and recovery.

The finding after death in young turkeys of the diseased and thickened cæca plugged with cheesy contents, together with the yellowish or yellowish-green spots in the more or less enlarged liver, is sufficient indication to warrant a diagnosis of blackhead.

Treatment.—The treatment of diseased birds has not given satisfactory results. The remedies most often used are: Sulphur 5 grains, sulphate of iron 1 grain; or benzonaphthol 1 grain, salicylate of bismuth 1 grain; or sulphate of iron 1 grain, salicylate of soda 1 grain. These remedies should be preceded and followed by a dose of Epsom salt (10 to 35 grains), or of castor oil ($\frac{1}{2}$ to 3 teaspoonfuls). One-third teaspoonful of catechu to the gallon of drinking water may also have a beneficial effect. It seems clear, however, that it does not pay to doctor the sick poults and that the only hope of success at present is in preventing their infection.

Prevention.—As already stated, the cause of blackhead is uncertain, and a good deal of uncertainty likewise surrounds the question of preventive measures. The measures which have been suggested by various investigators in most cases have been evolved upon the basis of the theory that the disease is caused by an amœba. Some of these measures are as follows: (1) Obtaining eggs from birds believed to be healthy; (2) wiping the eggs with a cloth wet with alcohol (80 to 90 per cent) before they are placed in the incubator or under the hen for hatching, to remove any contagion that might be on the shell; (3) hatching in an incubator, or at least removing the eggs from under the hen a day or two before hatching would occur, wiping with alcohol, and finishing in an incubator, in order to avoid exposing the poults to the hen; (4) placing the young poults on ground at a distance from all other domesticated fowls and not recently occupied by other fowls; (5) excluding, so far as possible, pigeons, other wild birds, and rats and mice from the houses and runs occupied by the turkeys; (6) frequent disinfection of the houses, feeding troughs, drinking fountains, etc.; (7) immediate killing of diseased birds and the destruction of their bodies by fire.

As measures for the disinfection of poultry yards into which blackhead has been introduced some investigators have proposed to dig up and burn the surface soil to a depth of several inches, which may be done with small yards but is not practicable with large ones. In most cases the poultryman must be contented with the application of a layer of freshly burned lime that has been carefully slaked to a fine, dry powder. After a few weeks this ground should be plowed and another layer of lime applied. The manure which has accumulated should be burned or mixed with lime and plowed into the ground of some distant field. The walls and floors of the buildings should be covered with a good limewash containing 6 ounces of carbolic acid to the gallon. The fences should receive a coat of limewash. The feeding troughs and drinking vessels should be put into a kettle of boiling water for half an hour. Troughs too large for this should be burned and replaced by new ones.

After these measures are adopted, assuming that blackhead is a contagious disease, the longer the premises are left vacant the more liable is the contagion to be completely destroyed, and the freezing and thawing of winter and spring will probably prove to be of great assistance. In beginning with a new flock the precautions already mentioned may be adopted to prevent a fresh introduction of the disease on the premises.

GOUT.

Gout is marked by the presence of an abnormal quantity of uric acid in the blood, which results in the deposits of urates on the internal organs (visceral gout), or more frequently in the joints (articular gout).

Causation.—The increased quantity of uric acid may be induced by several causes. Prolonged feeding on substances rich in albumin, especially if associated with lack of exercise, is probably the most frequent predisposing factor. Diseases which affect the urinary organs, causing a failure to eliminate the uric acid properly, play an important part in the causation of gout.

Symptoms.—The joints of the feet are most frequently and severely affected, although the wing joints may also be involved. At first the joints are swollen and painful. Later the lesions form into nodular, tumorlike growths which vary in size and may be either hard or fluctuating. Frequently the swellings burst, discharging a yellowish, turbid material containing urates. The bird avoids walking as much as possible and remains in a sitting position. The general health becomes affected, and emaciation gradually occurs, with weakness and frequently diarrhea.

Visceral gout is apparent on autopsy only. The internal organs and serous membranes are found covered with chalklike deposits. The course of the disease is slow.

Treatment.—Artificial Carlsbad salts have proved beneficial. This is prepared by mixing together sodium sulphate 22 grams, potassium sulphate 1 gram, sodium chlorid 9 grams, and sodium bicarbonate 18 grams. Six grams (or one-fifth of an ounce) of this mixture are added to 1 liter (or 1 quart) of drinking water. Tincture of colchicum in 2 to 5 drop doses per bird may also be used. Enlarged



FIG. 8.—Chicken affected with articular gout. (After Kionka.)

joints may be opened and the contents washed out. When moderately severe symptoms are shown it will be best to fatten and kill the bird before the onset of emaciation.

When several fowls in the flock develop symptoms, the diet should be looked into and corrected if necessary. Often a reduction in the quantity of meat scrap and an increase in the green feed will prevent further cases. The entire flock should receive a dose of Epsom salt, one-third teaspoonful to each adult bird.

Another good lice powder is flowers of sulphur, which should be applied with a duster. Although sulphur is considerably cheaper than sodium fluorid, it is less effective against lice and hence must be applied more liberally, so that a treatment with sulphur is in reality more expensive than with sodium fluorid. Many other powders, most of which contain pyrethrum (insect powder), are commonly used, but they have no advantage over sodium fluorid.

Dust baths containing a mixture of tobacco dust or other insecticides, and ordinary road dust are often recommended to destroy lice. While it is a good plan to let the birds dust themselves when they wish, no method which allows the bird to treat itself for lice can be expected to eradicate them all, since fowls can not get the dusting powder on all parts of the body where lice are, and many lousy birds will not use the dust bath.

It is possible and practicable to keep a flock of poultry absolutely free from lice and mites, and this should be the aim of every one who is endeavoring to establish a successful poultry industry.

MITES.

While there are many kinds of mites affecting poultry, there are three which are of especial importance to poultry raisers, the best known being the common chicken mite or red mite (*Dermanyssus gallinae* de Geer). In the Northern States this mite is dormant in winter except in chicken houses which are heated, but in the South it breeds and is active the year round, although it is always most abundant in summer. Unlike the other mites affecting poultry, this parasite is found on the birds only when it is feeding. It is nocturnal in habits, feeding at night and hiding during the day in the cracks of the roosts, in the nests, in the corners of the floor, and between boards. For this reason its presence often remains undetected until the chicken houses are badly infested and the poultry raiser seeks an explanation for the drooping condition and listlessness of his fowls.

To eradicate the pest a thorough cleaning of the chicken houses and spraying with a suitable disinfectant having a sufficient body is all that is necessary. All roosts, loose boards, and boxes should be removed and the disinfectant applied in the form of a rather coarse spray, using a suitable pump. Some of the best substances for the purpose are the so-called wood preservers which consist of anthracene oil and zinc chlorid. As a mixture of this kind is a little too heavy to spray well, it may be thinned with an equal part of kerosene. Crude petroleum is almost equally effective and is usually cheaper. It should be thinned by adding 1 part of kerosene to 4 parts of crude oil. Pure kerosene, kerosene emulsion, and carbolic acid are all

effective, but as they all lack sufficient body the spraying must be repeated a second or third time at 10-day intervals. The coal-tar dips, used in a slightly stronger solution than recommended on the labels, will prove effective if the application is repeated, and their germicidal properties are a desirable feature. Whatever preparation is used, the birds should be kept out of the houses until the fluid has thoroughly soaked into the wood.

Depluming scabies.—Fowls and pigeons are sometimes infested by an itch mite which lives at the base of the feathers, causing an intense itching and producing a disease known as mange or depluming scabies. The irritation caused by the mites leads the fowls to pull out their feathers, and they often acquire the habit of feather pulling, attacking the plumage of other birds as well as their own. If the stumps of the feathers are examined soon after the breaking of the quill, they will be found surrounded by scales and crusts, and the adjoining feathers when pulled out will be found similarly affected. In this way the condition can easily be distinguished from molting or the vice of feather pulling which fowls sometimes acquire without apparent cause. The mites causing the disease are introduced into the poultry yard by affected fowls and spread rapidly from fowl to fowl, finally infesting nearly all birds in the flock. The disease usually begins in the spring, is most active in warm weather, and disappears in winter.

The affected spots of the skin from which the feathers have dropped out should be anointed for some distance around them with an ointment made by thoroughly mixing 1 part of flowers of sulphur with 4 parts of vaseline or lard, or 1 part of carbolic acid with 50 parts of vaseline. A convenient liquid preparation is made by mixing Peruvian balsam 1 ounce and alcohol 3 ounces. One of these preparations should be selected and applied at least twice with an interval of a week or 10 days.

Scaly leg; mange of the leg.—Another species of itch mite attacking chickens, turkeys, pheasants, and cage birds is the cause of a condition known as scaly leg. While this mite is usually confined to the legs, it may occasionally attack the comb and wattles. The disease occurs in most cases as a result of contagion from other birds, although the mites may also be transferred from the roosts to the feet of healthy birds. It spreads slowly, and many individuals escape it entirely, although constantly exposed to it. (Fig. 11.)

The disease is easily recognized by the enlargement of the feet and legs and the rough appearance of the surface of the feet. The parasite begins its attack in the clefts between the toes and gradually spreads forward and upward until the whole of the foot and the shank become affected. The two legs are usually attacked about the same time and to the same degree. At first there is only a slight

roughening of the surface, but the continued irritation by the mite causes the formation of a spongy or powdery substance beneath the scales, which raises them more and more until they are nearly perpendicular to the surface and are easily detached. In the most severe cases the joints become inflamed, the birds are lame and scarcely able to walk, a joint or an entire toe may be lost, and the birds, unable to scratch for food, lose flesh and die from hunger and exhaustion.

For the treatment of scaly leg it is advisable to smear the roosts with wood preserver or crude petroleum as a precautionary measure



FIG. 11.—Scaly leg.

to prevent the further spread of the disease. The uninfested birds should be isolated from the infested, and the latter should have their legs washed with soap and warm water, removing all loose scales. Dry the legs and apply an ointment containing 2 per cent carbolic acid or the sulphur ointment or Peruvian-balsam wash previously mentioned. Another good remedy well recommended is made by mixing oil of caraway 1 part with vaseline 5 parts, or the caraway oil may be mixed with 5 parts of castor oil and rubbed gently into the skin. Some poultrymen who have large numbers of birds to be treated make a mixture of one-half pint of kerosene and 1 pint raw linseed oil in a quart can, take it to the poultry house at night and

dip both legs of each affected bird into the mixture, allowing them to drip into the can for a minute after removal, and then replace the chicken on the roost. The feathers of the leg must not be wet, as this causes irritation and sometimes burns the skin. The treatment should be repeated in three or four days.

Other mites.—Several other species of mites infest poultry. One of these bores into the skin and is found in cysts lying on the under surface of the skin next to the muscles. This form is not known to do any serious injury. Another species occurs in the air passages, liver, and lungs of chickens. Unless present in sufficient numbers to interfere with breathing, it is not a serious pest. Still other mites eat the feathers of the birds, but apparently cause little injury to the birds themselves.

Chiggers, or harvest mites.—Chiggers, harvest mites, or "red bugs," which so frequently annoy campers by the intense itching they produce, may also attack fowls. Young chickens having a free range, especially if it includes low-lying land, are the most liable to suffer from these parasites. The mites penetrate the skin, causing an intense itching, and abscesses may be found where clusters of mites are feeding. These abscesses are sometimes a third of an inch in diameter, surrounded by an area of inflammation. The birds become droopy, refuse to eat, and may die from hunger and exhaustion.

If an abscess has not yet formed the inflamed area may be treated with sulphur ointment, Peruvian balsam, or a mixture of 1 part of kerosene oil with 3 parts of lard. If suppuration has occurred the scab should be removed and the area washed with 4 per cent carbolic-acid solution. Frequent light dusting with flowers of sulphur will keep the chickens from becoming infested. In the Southern and Central States, where harvest mites are most numerous, it is often necessary to keep young chickens off the range in summer. In these sections it is a good plan to hatch the chickens early in the spring, so that when the warm weather comes, in which the mites are most abundant, the birds will be old enough to resist their attacks.

TICKS.¹

In some parts of the South poultry are commonly infested with a species of tick known as the chicken tick or adobe tick (*Argas miniatus*). This parasite when full grown may be one-fifth to one-fourth of an inch long, and is a powerful bloodsucker. In its adult stage of development it has feeding habits similar to the much smaller red mite in that it feeds only at night and spends the day hiding in cracks in the floors or walls. Pigeons are occasionally

¹ For further details concerning chicken ticks, see "The Fowl Tick," by F. C. Bishopp, Circular 170, Bureau of Entomology, U. S. Department of Agriculture.

attacked by a similar tick, and both species have been known to inflict painful bites on persons coming in contact with infested birds. These ticks, on account of their relatively large size compared with mites, can do a great deal of damage in a poultry or pigeon house, and young birds attacked by them are liable to succumb to exhaustion from loss of blood. Moreover, in the case of the chicken tick it is known that in some countries this parasite may itself be parasitized by minute organisms which are injected into the blood of the fowl which it attacks, causing a severe and usually fatal fever. In this way the tick acts as a carrier of the fever organism much as the mosquito by its bite carries the organism causing malaria to man.

The earlier stages of the chicken tick's development are passed entirely on the body, the tick leaving the birds only when it approaches the adult stage, but thereafter the adult tick attacks chickens only at night, after they have gone to roost.

Chicken ticks are very resistant, and ordinary insecticides have little effect upon them. If a chicken house is found to be infested with ticks, the chickens should be removed from it and housed in temporary coops for a period of 10 days at some distance from the chicken yard. This period of quarantine allows the young ticks that are present on the chickens to become engorged and fall off. If the chicken house is badly infested and is not of much value, it should be destroyed by burning. Otherwise, an attempt to disinfect it may be made after all loose boards and boxes which may provide hiding places for the ticks have been removed. Then crude petroleum or wood preservative may be applied as recommended for the treatment of red mites. The temporary coops in which the chickens have been quarantined should be burned or disinfected by dipping in boiling water.

A simple and inexpensive way of protecting chickens from the attacks of ticks is to suspend the roosts from the ceiling by means of small wires. The roosts are prevented from swaying by similar wires between the roosts and the walls of the house. Nests should be located away from roosting places and if constructed of metal can be disinfected quickly from time to time by burning out the straw.

Metal houses have been found to be effective in dealing with the ticks, as even without special attention they remain practically tick free, and if necessary they can be disinfected easily by a fire of straw, paper, or other light material, after removal of the roosts. Metal houses, however, are usually more expensive than wooden ones and are hot in summer and cold in winter. If they are used in summer the fowls should be provided with shade outside the house.

When ticks have once been eradicated from the premises no chickens should be added to the flock until they have been quarantined for

a period of 10 days in temporary coops, as already described. The coops should be destroyed after use, or thoroughly disinfected with hot water.

FLEAS.¹

In the Southern and Southwestern States poultry are frequently infested by a species of flea known as the chicken, or stick-tight, flea, from its habit of remaining attached to one place. This form also attacks dogs, cats, and some wild animals. On poultry the fleas are usually found in clusters on the comb, wattles, and around the eyes; on dogs they are found on the ears. Young fowls when heavily infested often die quickly. Older birds, while more resistant, have been known to succumb to heavy infestations, and even mild infestations will reduce egg laying and retard the growth of the fowls.

As a preliminary step in the treatment for fleas all dogs and cats should be kept away from the chickens and should never be allowed to lie on the ground in the chicken yards. As rats frequently harbor large numbers of these fleas and may therefore keep up the infestation, they should be destroyed by trapping, not only on account of the fleas they may carry but because they are themselves a serious pest to poultry. Chicken fleas breed in the cracks of the henhouses, and it is accordingly necessary to treat both the birds and their quarters. The combs and wattles of the birds may be anointed with carbolated vaseline or sulphur ointment. Great care should be taken, however, not to get any of the ointment in the eyes, as it may produce blindness. The henhouses and yards should be thoroughly cleaned out, sprayed with a suitable disinfectant, and then whitewashed with lime and carbolic acid as already recommended for mites.

CROP BOUND (IMPACTED CROP).

The affection known as "crop bound" or impacted crop is an overdistended and paralyzed condition of the crop, generally caused by overeating or by swallowing coarse and indigestible substances, such as feathers. In cholera the crop is paralyzed as a result of the disease.

The first symptom is a loss of appetite or an effort of the bird to swallow without being able to do so. The crop is seen to be very large and much distended with contents which are more or less firmly packed together. If permitted to continue, the condition becomes aggravated, the breathing difficult, and death may result.

The contents of the crop may sometimes be removed by forcing the bird to swallow a teaspoonful or more of sweet oil, then massaging the lower part of the gullet if it contains food, or, if not, the part of

¹ For further details in regard to chicken fleas, see Farmers' Bulletin 683, "Fleas as Pests to Man and Animals, with Suggestions for Their Control," by F. C. Bishop.

the crop nearest to the gullet, until a part of the contents are softened and may be pressed toward the head. This is made easier by holding the bird head downward. By continued manipulation the greater part of the material may be removed. The bird should not be permitted to eat for several hours after it is relieved.

If this plan of treatment is not successful, the crop must be opened with a sharp knife and the contents removed through the opening, using for this purpose a coffeespoon, a buttonhook, small forceps, a bent wire, or other suitable instrument. After this is done wash out the crop with clean, warm water. The opening should not be over an inch in length and should be closed with 3 or 4 stitches first in the wall of the crop and, when this is finished, an equal number in the skin. Each stitch should be made and tied separately. Coarse white silk is the best material, but if it is not at hand ordinary cotton thread may be used. Feed on milk and raw egg beaten together for a day or two, and gradually change to soft mash.

INFLAMMATION OF THE STOMACH OR INTESTINES.

Inflammation of the stomach or intestines, when not the result of one of the contagious diseases to which reference has been made, is generally due to eating moldy or putrid food or irritating mineral poisons. It is indicated by loss of appetite, dullness, and constipation, or diarrhea. It may be treated by giving 30 or 40 grains of Epsom salt or 2 teaspoonfuls of castor oil, and feeding a soft mash for a day or two.

LIMBERNECK.

The condition known as limberneck is in reality not a disease, but is a symptom of several diseases which are characterized by a paralysis of the muscles of the neck, which makes it impossible for the bird to raise its head from the ground. This condition is due to the absorption of poisons from the intestines, which act upon the nervous system and cause paralysis. It is generally associated with indigestion or the eating of moldy grain or putrid meat or with intestinal worms.

The best treatment is to give a full dose of purgative medicine—that is, 50 or 60 grains of Epsom salt or 3 or 4 teaspoonfuls of castor oil for a grown fowl. Often the birds will be cured within 24 hours. In case they are not better within 3 or 4 days it is not advisable to keep them.

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STANDARD BROOM CORN

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UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry

WM. A. TAYLOR, Chief

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BROOM CORN is used in the manufacture of brooms and brushes; it has no other value. It will grow in some part of almost every State in this country, but brush of good quality can be produced only under favorable climatic conditions and the right sort of handling, and, like the fox, it is its brush that counts.

Broom corn belongs to the sorghum family and makes its best growth in a warm, sunny climate. The varieties are divided into two groups, the Standard and the Dwarf. The Dwarf varieties are adapted to the high altitudes and dry climate of the southern Great Plains States, and the Standard varieties to the humid conditions in the Eastern and the central Western States.

A well-prepared mellow seed bed, pure seed of high germinating power, and clean cultivation are essential to the production of the highest yield of good brush. The time of harvesting, the care exercised in thrashing, the method of curing, and the condition of the brush when marketed are important factors in determining its value.

The price of the brush is governed largely by quality and supply. The demand has been about constant for the past 20 years. When production exceeds the demand, the prices of all grades fall very low. When the crop is short, prices are much higher, sometimes reaching \$400 or more per ton for brush of the best quality.

STANDARD BROOM CORN.

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NATURE AND USE.

BROOM CORN is grown only for the brush, which is used in the manufacture of brooms and brushes. Owing to its scant foliage, dry pith, and woody stalk, the plant has very little forage value. This applies especially to the Standard varieties. Because of these facts the value of the crop depends alone upon the market price of the brush. When the supply of brush is greater than the demand, the price falls below the cost of production, and when the crop is short and mostly of poor quality the price for good brush soars to almost prohibitive figures.

The price of broom corn is governed entirely by the domestic supply and demand. Only 1,000 to 2,000 tons are exported annually, and this small quantity does not affect the home market. The demand for brooms has remained about constant in the past 15 or 20 years, as vacuum cleaners and other devices of like nature have supplied the increased requirements for house cleaning, etc., due to the increase in population during this period. There is no apparent reason for a change in the demand for brooms in the near future; hence the demand for broom corn probably will remain unchanged.

HISTORY.

The origin of broom corn is not known. In Italy the growing of a sweet sorghum with a loose, open head for making clothes brushes dates back more than 350 years. It is likely, therefore, that broom corn is the progeny of a sorghum of this sort obtained through careful selection.

Broom corn has been grown in the United States at least since the year 1798. Until about 60 years ago New York and Virginia led in the growing of this crop; production since then has moved slowly westward. In 1899 it was centered in Illinois and adjacent States. Up to that time only the Standard broom corn was grown.

Within the 10 years from 1901 to 1910, Dwarf broom corn came into prominence, due to its adaptation to dry weather conditions, and

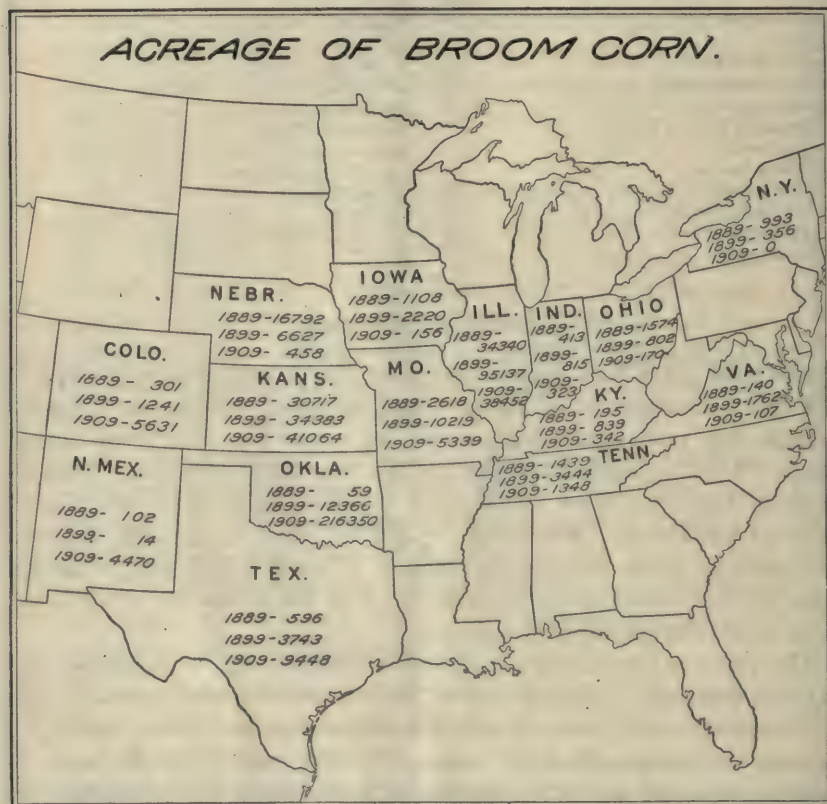


FIG. 1.—Outline map of the Central and Eastern States, showing the acreage of broom corn in each State in the years 1889, 1899, and 1909.

the center of production again moved westward, this time into Oklahoma. The Standard variety is grown in the Lindsay district of Oklahoma, but the remainder of the crop in the State is practically all of the Dwarf variety. The Lindsay district includes the bottom lands along the Washita River in the counties of Garvin, Grady, and McClain. This district grows from 20,000 to 30,000 acres of broom corn annually and produces a good grade of brush under normal conditions. The Lindsay brush has won an excellent reputation and is sought by the manufacturers.

In 1917, Oklahoma had 175,000 acres in broom corn and produced 26,250 tons of brush. This was more than 58 per cent of the acreage and over 50 per cent of the total quantity of brush produced in the five leading broom-corn States that year. Kansas, with 60,000 acres, took second place in acreage devoted to the crop, and Illinois and Colorado tied for third place with 30,000 acres each. Texas was the fifth State in point of acreage and production. Kansas produced 12,000 tons, Illinois 8,250 tons, and Colorado 4,650 tons of brush. Kansas, therefore, ranked second in production and Illinois third.

The acreage devoted to broom corn in the Eastern States has decreased in the last 15 or more years. A decided decrease took place in these States in the 10-year period from 1899 to 1909, inclusive. This is shown in figure 1.

CLIMATIC ADAPTATION.

Broom corn has a wide range of climatic adaptation, but grows best in a warm, sunny climate. It is more drought resistant or drought evasive than corn and can do better on a limited supply of water. Cool nights check the growth of broom corn, even when followed by days of moderate or intense heat. When grown under such conditions the fiber usually becomes coarse and brittle and is of poor quality.

This crop can be grown in almost every State in this country, but the best quality of brush is produced only under favorable conditions and with the right sort of handling at and following harvest. Dry, sunny weather at harvest time is favorable to curing the brush so that it will retain the natural green color. Excessive rain at this time is detrimental to color and quality, the brush becoming weather stained or red.

GROUPS OF BROOM CORN.

There are two chief kinds of broom corn, the Standard and the Dwarf. These differ mainly in the height of the plants and in the length and texture of the brush. Standard broom corn makes up about one-third of the total crop of this country at present. It grows from 10 to 14 feet in height, according to soil fertility and seasonal conditions. Normally the brush varies in length from 18 to 24 inches, and the head grows entirely out of the upper left sheath, or boot. The fiber usually is round and pliable but not as fine as that of the Dwarf variety. It is flat and coarse and of poor quality when produced under unfavorable conditions. Standard broom corn requires more water than the Dwarf and therefore is better suited to culture under humid conditions. This bulletin will be devoted to the culture of Standard broom corn, as Dwarf broom corn has been discussed in another publication.¹

¹ Rothgeb, B. E. Dwarf broom corns. U. S. Dept. Agr., Farmers' Bul. 768, 16 p., 7 fig. 1916.

The Standard varieties grow taller than the Dwarf, and the main stem of the head, or brush, is more firmly attached to the upper joint, which does not permit the brush to be harvested by pulling or "jerk-ing." The head not being inclosed in the upper leaf sheath, or boot,



FIG. 2.—Heads of broom corn: (A) Good type, round fiber; (B) coarse, flat fiber; (C) crooked head; and (D) poor, short fiber and a large central stem.

does not permit water and plant lice (aphides) to accumulate there and damage the brush. For this reason the Standard varieties are better adapted to humid conditions.

Many varietal names have been applied to Standard broom corn. Some of these are Australian, California Golden, Chinese Evergreen, Early Longbrush Evergreen, Evergreen, Imperial Evergreen, Improved Evergreen, Missouri Evergreen, and Tennessee Evergreen. These names are not very important, as they do not represent distinct varieties. In many cases they are local names. What the grower should know is whether he is getting seed of high germination, selected from brush of good quality. The manufacturer wants to know the quality of the brush he is buying regardless of the name applied to it. Broom-corn heads of good and of poor quality are shown in figure 2.

GROWING THE CROP.

Broom corn requires practically the same cultural treatment as other sorghums or corn. Like corn, it makes its best growth on rich friable soils. The cultural requirements depend largely upon the nature of the soil and the season. The crop should be given the treatment that has proved best for corn on the different soils in any given locality.

PREPARING THE SEED BED.

A well-prepared mellow seed bed is essential to success. This permits sowing the seed at a uniform depth. All the young plants will then emerge to a good stand at about the same time, and the brush will develop more uniformly.

The time and depth of plowing depend entirely upon the nature and condition of the soil. In east-central Illinois the most successful growers of broom corn use clover-sod land for this crop. The land usually is plowed in the fall but left without further treatment until spring. Then it is worked with disk and spike-tooth harrows into a deep, even seed bed. Shortly after sowing, but usually before the young plants emerge, a corrugated roller is run over the field. This pulverizes all the clods and breaks the surface crust. The land is then in good condition for further cultivation. This method of preparing the seed bed is applicable to other States with similar conditions and may be modified to meet emergencies.

GOOD SEED.

A good stand and a uniform crop are essential to the maximum yield of brush of good quality. These can be obtained only by using pure seed of high germination. The grower should know not only the quality of the seed, but also the kind and quality of brush from which the seed was thrashed. Broom corn crosses readily with

all varieties of sorghum, including Sudan grass and Johnson grass. Seed from such crosses or hybrids produces worthless brush and should not be used.

Broom-corn seed is obtained commonly from three sources: (1) From growers who make a business of growing the seed for sale, (2) from the piles of seed which accumulate at the thrashers, and (3) from the field or seed plat of the grower or his neighbor. There are serious objections to the seed derived from the second source and sometimes objections to that from the first.

SEED FROM PRIVATE GROWERS.

Private growers who specialize in broom-corn seed usually produce seed of good quality from varieties or strains adapted to conditions under which the crop is grown. Most of these growers of the Standard variety are located in east-central Illinois, and this seed is very well adapted to the humid conditions of the Eastern and Southern States. The best results can not be obtained from seed when it is sown in a locality where the conditions are quite unlike those under which it was produced. Home-grown seed of good quality usually produces a better crop than imported seed of the same quality. Each farmer should grow his own seed or obtain it from some one in his locality who specializes along this line.

SEED FROM BROOM-CORN THRASHERS.

The broom-corn thrasher is unquestionably the most undesirable source from which seed may be obtained, as seed from all kinds and qualities of brush is mixed in thrashing. The seed from brush of good quality with round fibers can not be separated from that of poor quality with coarse, flat fibers, twisted and burly heads, and hybrids. No matter how carefully this seed is cleaned and graded by the use of a fanning mill, the good seed from desirable brush can not be separated from that of poor brush and hybrids. The brush is harvested somewhere between the flowering and dough stages, and the greater part of the seed is immature and will not germinate. It is not possible, therefore, to grow a crop of desirable brush from such seed.

Broom corn is subject to smut. When seed is obtained from unknown or mixed sources, the likelihood of getting smut-infested seed is very great. If smutted seed is sown, unless it is first treated to destroy the disease there is sure to be a large percentage of smutted heads in the resulting crop. This causes heavy loss to the grower, as smutted brush is of little or no value. The seed on good brush becomes infested also and endangers the future crop.

The kernel smut is the common smut of broom corn. It can be destroyed by the formalin treatment of the seed, which is easily and cheaply applied. All seed not known to be free from smut should be so treated before it is used for sowing purposes. Directions for smut treatment are given on page 18.

SEED FROM A HOME SEED PLAT.

The home seed patch, if properly handled, is the ideal source for broom-corn seed. The grower can be absolutely sure of the quality of his seed from this source. He has as good seed as that produced by any commercial grower, and he eliminates the chance of getting poor, mixed seed from unknown sources.

The best seed obtainable should be used. As the plants approach the heading stage, all that are not true to the variety sown, as indicated by different heights, sizes, shapes, or colors, should be removed from a few rows on one side of the field. The remaining plants in these rows should be inspected frequently as the brush begins to emerge from the boot. All spiky brush, or that with a large central stem, should be removed before it flowers and cross-fertilizes the good brush. If this work is well done the first year, much less time will be required in the second and succeeding years.

SOWING THE SEED.

The main factors in sowing the seed are (1) when to sow, (2) how much to sow to the acre, and (3) how to sow.

WHEN TO SOW.

The time to sow broom corn differs with the locality and even within the same locality. Sowing should not be done too early. The seed does not germinate well in a cold soil, and a poor stand results.

The early crop of broom corn usually is sown in the Lindsay district in Oklahoma about April 15. In central Illinois sowing begins about April 25 if conditions are favorable and, if a large crop is sown, continues at 10-day intervals until finished. Thus the crop is not all ready to harvest at one time, which avoids loss from the brush becoming overripe before it can be harvested. How late in the year sowing may be delayed and the brush still mature depends upon weather conditions in the early fall. Growth is checked by cold nights, and a heavy frost will kill the plants. In localities where frosts are not likely to occur before about October 1, good crops sometimes are grown if sowing is delayed until July 1. Normally from 80 to 90 days are required for the brush to mature. More time is required to mature a seed crop.

HOW MUCH SEED TO SOW.

The rate of sowing broom corn depends largely upon the fertility of the soil and on seasonal conditions. From 2 to 3 pounds of good, clean seed are required to sow an acre where the rows are $3\frac{1}{2}$ feet apart. This will produce an average stand of one plant in every 3 to 5 inches of row space. Sowing should be done at a heavier rate on rich soil than on poor soil. Thin stands on rich soils tend to produce long, coarse brush. Thick stands on poor soils may produce short brush or, in extreme cases, none at all.

HOW TO SOW THE SEED.

In districts growing Standard broom corn, except in the Lindsay district in Oklahoma, the seed usually is sown with an ordinary corn drill fitted with special plates. It may be either surface-sown or listed. The latter method is practiced almost exclusively in the Lindsay district. That method should be used which has proved best for other sorghums or corn in any given locality. The seed should be placed about 1 inch deep in a well-prepared moist seed bed. Deeper seeding may be necessary in dry soils.

Broom corn plates usually can be obtained from the manufacturer or the local implement house, or blank plates may be obtained and drilled by a blacksmith or by the farmer. The number and size of holes in the plate required to sow a given rate depend to some extent on the speed adjustment of the corn drill, which differs in the different makes. The speed adjustment of the drill to be used should be learned and the number of holes in the plate required for a given rate then determined. The holes should be not less than three-sixteenths of an inch in diameter and slightly countersunk on the under side, so that the seed will not wedge fast in the hole. Holes one-fourth of an inch in diameter are preferred by some successful growers. Seeding will have to be done at a heavier rate than the stand desired, because all of the seed will not germinate.

CULTIVATING.

Thorough cultivation is essential to the production of a full crop of good brush. The young plants grow slowly at first, and the crop will be seriously damaged if weeds are allowed to grow in large numbers. In fact, the total destruction of the crop may result if the weeds get an early start. Harvesting is made more tedious and expensive when the field is full of large weeds. Cultivation should be begun early and repeated often enough to destroy all weeds and to keep the soil in a loose condition, so that the rain will be absorbed readily and loss of moisture from "run-off" or injury to the crop by standing water will be reduced to the minimum.

The first cultivation should be given with either a corrugated roller or a spike-tooth harrow before the young plants have emerged. This will break the surface crust and permit the plants to emerge uniformly, and it will destroy young weeds which are appearing in the surface soil. The second cultivation should follow a few days after the crop is up, but before the plants are large enough for the work to be done satisfactorily with an ordinary cultivator. For this the spike-tooth harrow will be the most efficient. The harrow teeth should be slanted backward, so that they will not cut into the ground deep enough to injure the plants. Later cultivations may be made with the ordinary corn cultivator. Under normal conditions three such cultivations are sufficient. On land where weeds are bad more cultivations will be required. These should be as frequent as may be necessary to keep down the weeds and to keep the soil in good tilth. Cultivation should be continued until the plants are too large for the team and cultivator to pass between the rows without injuring the crop.

HARVESTING THE BRUSH.

The value of the brush depends largely upon the stage of maturity when harvested. If the brush is harvested when too young the fiber is weak at the base of the head, and when harvesting is delayed until the brush is overripe the fiber becomes hard and brittle. Good service can not be expected from brooms made of such brush.

WHEN TO HARVEST.

The brush should be harvested when it has reached the stage where the natural green color extends from the tip of the fiber to the base and center of the head. This usually occurs from the time when the flowers are falling to the time the seed is in the milk or thin-dough stage. Brush harvested in this stage and properly cured, without being damaged by the sun or wet weather, is tough and flexible and of the best quality.

If a seed crop is desired the brush is not harvested until the seed is fully mature. The value of ripe brush depends largely upon the climatic conditions previous to harvest and the care given the brush after the seed is removed. If seed brush is not discolored by wet weather, but has the natural yellow color of mature brush, it commands about half the price of good brush if cared for in the same way.

METHODS OF HARVESTING.

Standard broom corn and Dwarf broom corn are harvested in different ways. The Standard is bent over or tabled and the brush cut off; the Dwarf is jerked or pulled from the upright stalk.

The Standard varieties are so tall that the stalks have to be bent over to bring the brush within reach. This process is called tabling. The tabler walks between two rows, bending or breaking the stalks over, 3 or 4 feet from the ground. The stalks of the left-hand row are bent to the right and those of the right-hand row to the left. This crosses the stalks of these rows, so that a sort of table is formed behind the tabler, the brush projecting across the table into the spaces between this pair of rows and the next row on either side. A field of broom corn partly tabled, with the heads harvested and lying in bunches on the table, is shown in figure 3.

The brush is harvested by walking in the space between the tables and cutting the heads from the stalks with a jackknife or a knife with a short, wide blade made especially for that purpose. The stalk should be cut so as to leave about 6 inches of stem with the brush. All leaf sheaths, or boots, should be removed as the heads are cut. The knife should be held firmly with the cutting edge pointing at an angle from the body. If the head is then grasped with the other hand and the stalk pulled against the knife, instead of forcing the knife against the stalk, the stem of the brush will usually slip out of the boot as it is being cut from the stalk. As the heads are cut they are laid in handfuls on the table. The brush should be hauled to the curing shed and thrashed the same day it is harvested, or at any rate not later than the following day.



FIG. 3.—A field of broom corn, partly tabled, showing the harvested heads lying in piles on the table.

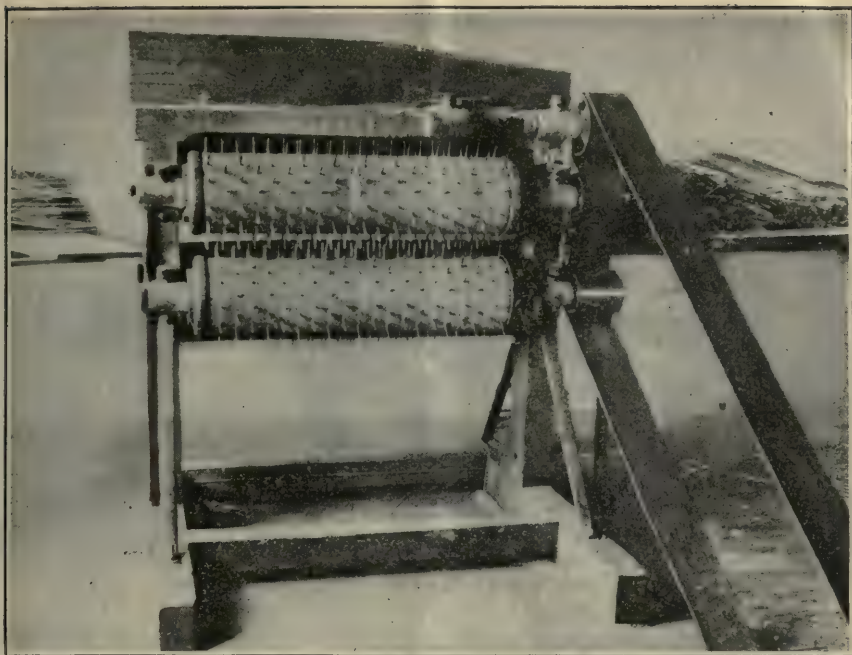


FIG. 4.—Rear view of a hand-fed broom-corn thrasher.

THRASHING.

The broom-corn thrasher, constructed especially for this crop, consists essentially of two horizontal cylinders, one about 3 inches above the other, revolving in opposite direction. The surfaces of both are set with teeth or spikes. The spikes project about $1\frac{3}{4}$ inches from the surface and are set 3 inches apart in rows 1 inch apart, running lengthwise of the cylinders. The spikes alternate in the rows running lengthwise, so that the rows around the cylinders are formed by the spikes of alternate rows running lengthwise.

There are now in common use two different makes of these thrashers, one hand fed and the other self fed. The main differences in these machines are the method of feeding and the capacity. In thrashing with the hand-fed machine, the feeder stands directly in front of the cylinder. The brush is grasped firmly by the stems at the base and the tips are inserted between the cylinders and held there until all the seed is removed. The brush is then withdrawn. A rear view of a hand-fed thrasher is shown in figure 4.

The heads are carried to the cylinders of the self-fed machine by a sprocket belt. This belt passes in front of the cylinders and parallel to them. It holds the heads firmly by the stems and is so adjusted that only the seed-bearing tips pass between the cylinders. The seed is stripped from the brush as it passes along to be deposited

on a table beyond the cylinders. The capacity of this thrasher is much larger than that of the hand-fed one, and more help is required to operate it. A view of a thrasher of this sort is shown in figure 5.

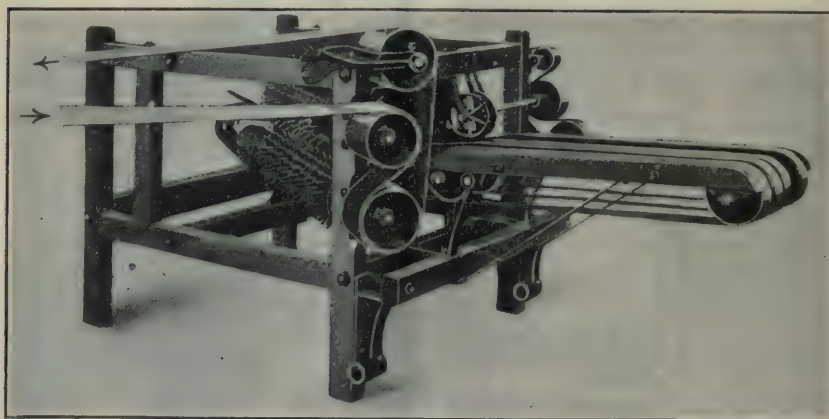


FIG. 5.—Side view of a self-fed broom-corn thrasher.

The hand-fed thrasher does as good work as the self-fed one, but is recommended for use only where small lots of brush are to be thrashed. Time saved in thrashing shortens the risk of exposure to damage by unfavorable weather conditions.

In thrashing broom corn all the seed should be removed from the brush, but as little as possible of the fine fiber should be torn off with the seed. For the best results the heads should be fed into the thrasher straight and in small handfuls. Otherwise a good job of thrashing can not be expected and the loss of fiber will be much greater.

CURING.

The value of the brush often is determined in the process of curing. Color and condition govern the price to a large extent. The highest quality of brush is obtained only when proper precautions are taken in curing it. It is essential that the brush be cured rapidly and not exposed to strong sunlight, in order to be in the best condition and retain the natural green color.

SHED CURING.

The best method of curing the brush, in sections where the Standard variety may be grown, is in a shed built for the purpose. About 1 cubic foot of space is required for each 2 pounds of cured brush. A shed 10 feet high, 16 feet wide, and 24 feet long will furnish ample space for green brush that will make about $3\frac{1}{2}$ tons after curing. This is equal to the average yield of about 12 acres in the central Illinois district.

A curing shed need not necessarily be expensive. It consists chiefly of a framework of heavy studding 10 feet high to the plate, supporting a roof with widely projecting eaves. The gables are sheathed, but the sides and ends usually are left open to permit free circulation of air. Sometimes the end and side in the direction from which rains usually come are sheathed also to protect the brush, leaving a space near the ground for the circulation of air. In many cases the grower cures his brush in a wagon shed, cattle shed, or straw shed. These sheds are usually open on one or both sides, which permits the air to circulate but protects the brush from the sun and wet weather. The brush occupies the shed but a few weeks in autumn and leaves it available for other uses the remainder of the year. From two to three weeks are required for the brush to cure, depending on weather conditions.

The brush is cured in shallow layers spread on a series of shelves. For convenience in arranging these shelves the shed should be divided into sections about 8 feet wide by setting posts 8 feet apart in rows lengthwise of the shed. To these posts should be nailed strips of boards at least 1 inch thick and 2 inches wide, running crosswise of the shed. Beginning near the ground these strips should be placed 6 inches apart from center to center until the plate is reached.



FIG. 6.—A curing shed filled with brush in the process of curing.

The shelves are formed by laying 2-inch slats in pairs with their ends resting on the cross strips. The members of each pair are placed just far enough apart to support the brush. The shelves are put in place only as fast as needed while filling the shed.

The brush is usually placed in the shed from one side only, in which case the first layer is placed at the bottom on the opposite side. The next layer is placed above the first and so on to the top until that section of the shed is filled. The brush should be spread evenly, not more than 2 or 3 inches deep on the shelves, so it will dry quickly. If the brush is placed too deep on the shelves it may become moldy and brittle while curing. A shed of brush in the process of curing is shown in figure 6.

If thrashing is done while the brush is green, fewer fine tips of the fiber are torn off with the seed than when thrashing is delayed until after the brush is cured. For the best results with the least risk of damage from wet weather, all brush harvested in any one day should be hauled to the shed before night. The following morning this brush should be thrashed and placed on the shelves to dry. If the brush is handled in this manner there will be no loss from weather-stained or sun-bleached brush.

PREPARING FOR MARKET.

The market value of the brush normally depends to a large degree upon its condition. Much of the season's profit may be lost by careless handling after the crop is cured. Careful grading, baling, and storing are important.

GRADING.

The brush should be graded before it is baled. Crooked heads, heads with twisted or burly fiber, and those with a large center stem are of poor quality and should be separated from the good brush. Grading can be done conveniently either when the brush is being taken from the field, after it is thrashed, or just before the baling is done.

The practice of baling the crop without grading is a common source of loss to the grower. Where good and poor brush are mixed, the buyer will estimate the percentage of poor brush a little higher than appearances indicate, in order to be on the safe side. The price paid under such circumstances usually is less than the total price the good brush and poor brush would have brought if baled separately. In most cases the grower will be well repaid for the time and labor devoted to grading his brush and baling each grade separately.

BALING.

The brush should be taken up in small armfuls and butted against a board, so that all the butts are even. It should then be placed in the baler, with the butts set firmly against the end of the baler. The butts of one armful are placed against one end and those of the next armful against the other end, continuing the process until the baler is full. The bale is then pressed into shape and the wires fastened. If the bale is pressed tightly and the wires properly adjusted, a good square bale will result. A well-made bale is shown in figure 7.

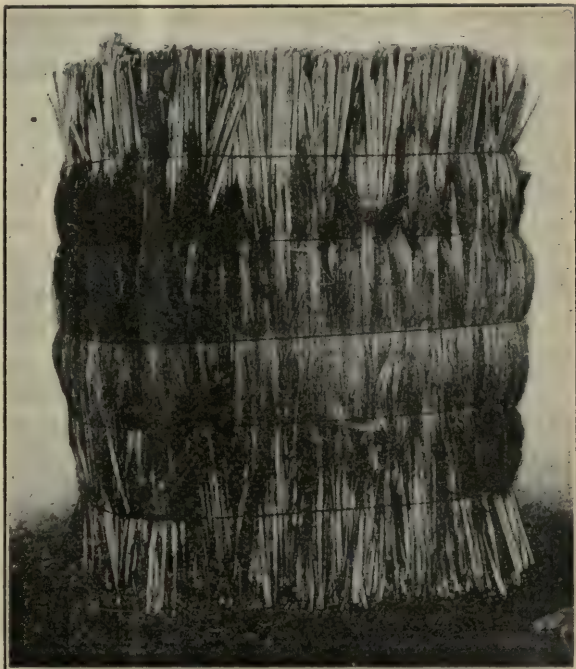


FIG. 7.—A well-made bale of broom corn.

Baling should not be done until the brush is dry enough to eliminate all danger of its molding in the bale. If baling is delayed indefinitely after the brush is dry, it should be bulked and protected from the light or it will bleach.

STORING.

The bales should be stored in a dry, dark place for protection from the weather and sunlight; otherwise the outside will be weather stained or bleached by the sun, and they will not bring as high a price as if kept in good condition.

DISEASES.

Smut is the common disease of broom corn. The crop is subject to two kinds of smut, the kernel smut (*Sphacelotheca sorghi*) and the head smut (*Sphacelotheca reiliana*).

The kernel smut is the more common of the two and may cause great loss if not kept under control. The kernels are replaced by black masses of smut spores, but the head retains its usual form

and almost its usual appearance. The fiber is brittle and of poorer quality than that from noninfested heads.

When the plant is affected with head smut, the whole head is converted into a large smut mass covered by a whitish skin or membrane. This membrane soon bursts and sets free the black mass of spores. The brush is an entire loss when this smut appears.

TREATMENT FOR SMUT.

Kernel smut can be destroyed by treating the seed with formaldehyde solution. Mix 1 pound of commercial formaldehyde with 30 gallons of water in a tub or barrel. Put the seed in sacks and soak in this solution for one hour, stirring it occasionally. Then drain the sacks and spread the seed on a clean floor or canvas to dry. The floor or canvas and the sacks into which the dried seed is put should be treated with the solution, as the seed will be infected again if any untreated smut spores touch it.

The solution may be used also as a spray. To use it in this way, spread the seed on a clean floor or canvas and sprinkle with the solution. The seeds must be stirred until all of them are wet. Shovel the seeds into a pile, cover with a treated canvas to keep in the fumes, and leave over night. In the morning spread the seeds out thinly to dry. The soaking or immersion method is more thorough, but perhaps not as convenient as the sprinkling method.

There is no known seed treatment effective against head smut. If possible, keep it off the farm. When it is present the diseased plants should be gathered and burned before the spores are scattered by the wind. This smut is not abundant except in certain small, unimportant districts.

PROFIT AND LOSS.

The profit or loss on a broom-corn crop depends, of course, upon the cost of production and the yield, quality, and market price of the brush. It is an expensive crop to produce, because of the large amount of labor required in the short time in which this work must be done and the special machinery required to handle the brush properly.

COST OF PRODUCTION.

The cost of producing a ton of brush has been placed at from \$35 to \$50 by successful growers in the States where most of the crop is grown. The expense varies in different localities, due to differences in land values and in the cost of labor. It costs little, if any, more under favorable conditions in a given locality to produce a good grade of brush than a poor one. The difference in price between good and poor quality will more than cover the added expense required to

produce good brush. The cost of the special machinery, such as the thrasher and the baler, may be much reduced to each grower if purchased in partnership by several. When labor is scarce, this problem may be partly solved by combining forces.

MARKETING.

The brush can be marketed to best advantage in carload lots, because of the difference between freight rates in full cars and smaller lots. The brush runs about 6 bales to the ton and from 10 to 12 tons to the carload. Community cooperation is needed to obtain the greatest success in growing broom corn. This will make possible marketing the crop in carload lots, with a consequent saving in freight. The manufacturers are more likely to send an experienced buyer into such a community, and it is possible for a community to grow a uniform grade of brush which will be recognized and sought at a premium by the manufacturer.

Good brush of uniform quality always brings a much higher price than poor brush. The prices on all grades vary widely in different years and sometimes in the same season, depending upon the quality and supply. When the production is large the price drops very low on all grades. Under such conditions the poorer grades may sell very slowly at from \$20 to \$25 per ton, while the better grades bring from \$50 to \$60 per ton. When there is a scarcity prices are much higher, sometimes reaching \$400 or more per ton for the best brush. Normally the market price for good brush ranges from \$75 to \$100 per ton, but during the years 1916 and 1917 the price was much higher.

YIELD.

The yield of broom corn varies in the different States and in the same State in different seasons. Season, soil, and cultivation are important factors in this regard. When these factors are favorable the highest yield of good brush is produced.

During the last 30 years more than 93 per cent of the brush produced in the United States was grown in 16 States. The total production in the years 1889, 1899, and 1909 was 19,278, 45,475, and 39,479 tons, respectively. Oklahoma now leads in production. In 1909 that State produced 21,371 tons, which was about 55 per cent of the total crop in that year.

The reports of the Bureau of Crop Estimates show that Oklahoma, Illinois, Kansas, Colorado, and Texas, in the order named, were the leading States in the production of broom corn in the years 1915 and 1916. The total production of these five States was 52,242 and 37,855 tons, respectively, in these two years. About 27 per cent of this was of the Standard variety and the remaining 73 per cent of the Dwarf

variety. In 1917 these five States produced 51,838 tons of broom corn, Kansas standing second in production.

USE AND VALUE OF THE STOVER.

Broom-corn stover consists of the stalks and leaves remaining after the brush is removed. This may be harvested and used either as silage or dry roughage, or it may be pastured. An economical way to dispose of the stover of the Standard variety, and the one commonly practiced, is to use it for pasture and later turn under as fertilizer what remains. Because of the tangled condition of the tabled stalks, harvesting the stover for feed is too laborious and expensive to be justifiable.



The SPOTTED GARDEN SLUG



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FARMERS' BULLETIN 959
UNITED STATES DEPARTMENT
OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

WASHINGTON, D. C.
JUNE, 1918

GARDENERS, MUSHROOM GROWERS, AND TRUCKERS frequently observe irregular holes in the foliage of such crops as lettuce, tomato, peas, and beans, either grown under glass or in the open, and mushrooms from which holes have been cut as by a mouse or rat. By close observation a glistening whitish substance will be seen on the plants or near by, and search under stones, old boards, and rubbish will disclose the cause of the injury—the garden slug.

Attack is most severe on delicate seedlings, but various tubers and roots are subject to injury. Potatoes are bored into and celery is frequently damaged during the bleaching process.

Garden slugs are not insects, although their injury is similar and they are sometimes called insects. They are mollusks and therefore related to the snails, although they have no external shell.

This bulletin describes the habits and development of the spotted garden slug and explains how to rid the premises or grounds of this destructive and otherwise undesirable tenant. The standard remedies for this and the other injurious garden slugs are lime, finely powdered salt, road dust, or other powders. Poisoned baits consisting of boiled potatoes or sweet potatoes sprinkled with arsenic are useful. The garden and greenhouse should be kept clean and free from rubbish and the slugs should be collected at night when they emerge from their hiding places.

THE SPOTTED GARDEN SLUG.¹

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PLANTS AND PLANT PARTS INJURED.

THE SPOTTED GARDEN SLUG (fig. 1) in recent years has attracted considerable attention by its depredations in gardens, greenhouses, and mushroom beds. Its fondness for fungi makes it a serious pest when once it has gained access to a mushroom house. In a greenhouse its attack usually is confined to young, tender seedlings, but ornamentals are rendered unsightly and unsalable by the trail of mucus which exudes from the animal's body, as it crawls from place to place. It frequently is abundant in gardens, especially in cool, damp seasons; often causing serious loss to growers of such plants as celery, lettuce, peas, and beans.

WHAT THE SLUG LOOKS LIKE.

The spotted garden slug is one of the largest land mollusks of its kind and often attains a length of 7 inches when fully extended.

¹Thirty-two species of garden slugs have been reported for the United States. Of these, four are introduced forms. Most of the native species are comparatively harmless so far as their ravages on crops and gardens are concerned. The conditions produced by the opening of the land for agricultural pursuits have effected decided hardships and forced them into the background. The larger west American slugs, however, some of which attain almost a foot in length, are occasionally an exception to this rule.

The real pests of our gardens, cellars, and wells are three introduced species, the spotted garden slug, *Limax maximus* L., ably discussed in this bulletin; the tawny garden slug, *Limax flavus* L., which is a smaller species rarely attaining a length of over 4 inches, and readily distinguished from the larger spotted garden slug by having the body of a more or less uniform dusky yellow shade with obsolete lighter yellowish spots and a tawny yellow shield and bluish tentacles, and the true garden slug, *Agriolimax agrestis* L. The last is probably the greatest pest of all the slugs in our country at present. It is a much smaller species, scarcely exceeding an inch and a half in length and much more often scarcely attaining an inch. It varies from uniform whitish through pale ochraceous, sometimes to lavender, purplish, or even almost black, with mottlings and specklings of various shades of brown. This little form, on account of its small size, can hide away in crevices to a much greater extent than the larger species, and therefore it is exceedingly abundant in city gardens, where it outnumbers the larger forms probably by 20 to 1. This may be considered the most important of the destructive slugs in our country at the present time. On account of its smaller size it has been transported more frequently to the interior than the other two species, which at the present are still largely distributed coastwise.

The remedies suggested for the destruction of the spotted garden slug will apply to any of the American species as well as to the other introduced forms. It may be well to add that, in the case of cisterns, wells, and cellars, sulphur fumigation has proved effective.—PAUL BARTSCH.

The individuals more generally found range in length from $1\frac{1}{2}$ to 4 inches. The slug varies in color from a more or less yellowish gray or brown, mottled with black, to uniform dark gray and black. Usually three uninterrupted rows of black spots extend from the mantle, or shield-like covering on the fore part of the back and sides, to the hind end of the body (fig. 1). The younger forms usually are uniform in color. The mantle is yellowish, marked with black spots. The large breathing opening is situated on the right side near the base of the mantle. The long, stout "horns," or peduncles, which are thrust forward when the slug is in motion, bear the black eyes at the tip. A sticky mucous secretion exudes from the body of the creature.

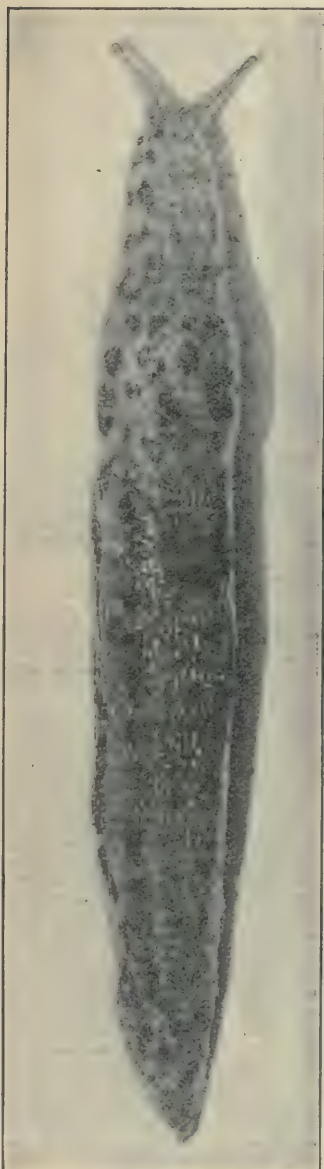


FIG. 1. — The spotted garden slug, full grown. About natural size.

HISTORY AND DISTRIBUTION.

The spotted garden slug was first described in 1758 by Linnaeus, who found it in shaded places and woods. Its first appearance in the United States does not seem to be definitely recorded, but its occurrence in New England extends over a period of upwards of 50 years. The species is widely distributed, being known all over Europe, in Asia Minor, Corsica, Sicily, Sardinia, the Azores, Madeira, New Zealand, and the United States. It is more abundant along the Atlantic and Pacific coasts than in the interior of the United States.

FOOD AND HAUNTS.

This slug attacks plants of many kinds. Its favorite foods are fungi and stored tubers, but it is also fond of raw beef and sour milk. It has been recorded as feeding on lettuce (fig. 2), celery, tomato, parsnip, carrot, strawberry, beet, turnip, cabbage, onion, leeks, melons, beans, peas, white potato, sweet potato, and common grasses. It displays considerable fondness for the foliage of violets.

The spotted garden slug thrives in dark and damp locations, such as those under old decaying boards and logs, under board walks, in cellars and creameries, along hedgerows, and beneath damp refuse.

NATURE AND EXTENT OF INJURY.

The slug injures the plant by gnawing large irregular holes in the leaves or by cutting off the stems, and by leaving after it a trail of sticky mucus on the plants and along the ground. Injury to mushrooms (fig. 3) is especially severe, the large holes cut by the slug ruining them for the market. Potatoes, both Irish and sweet, when



FIG. 2.—Work of the spotted garden slug on lettuce.

stored in damp, cool cellars, are also subject to attack. The slug is not content to feed on one tuber until that is entirely destroyed, but will pass from one to another, nibbling small holes in the potatoes near the edge of the pile or container. Celery in the beds during the bleaching process often harbors large numbers, which seriously damage the stems.

HABITS.

Soon after emerging from the eggs the young slugs move about in search of food. This consists of such material as is near at hand, since the young do not wander far. They remain four or five weeks

in a colony in the location where the eggs were deposited. The slugs remain under cover until nightfall and then come out to feed. The "homing" instinct is well developed in this species, and these slugs will return to the same place night after night unless disturbed, or unless the place becomes too dry for habitation. During their nocturnal excursions they shun all dry, dusty, or sharp surfaces. The route of the slugs back to their daily abode usually is the same as that taken when going forth. When full grown the slugs will travel long distances and overcome many obstacles in search of their favorite food. In confinement these creatures will attack one

another, and when the weaker succumbs its body is devoured.

DESCRIPTION.

THE EGG.

The eggs are deposited in masses, held together by a light-colored substance, in moist places, such as under decaying boards, flowerpots, and refuse. Sometimes they are placed beneath the surface of the ground under clods of earth.



FIG. 3.—Work of the spotted garden slug on mushroom.

The translucent, light yellow eggs, with tough and elastic outer membrane, usually will be found in masses of from 50 to 70, though the writer has found 106 in one mass, and one female has been known to deposit 112 eggs in two days.

THE SLUG.

The newly hatched slug when extended is a little less than half an inch long and about one-seventh as wide as long. It is dull white, showing no coloration except where the dark eyestalks can be seen through the transparent mantle. In a few hours after hatching the mantle begins to darken, and in about two days the whole body of the animal has turned still darker, three broken longitudinal lines appearing, which run from the base of the mantle to the hind end of the body. The mantle then changes to a mottled gray. As the animal feeds it becomes of a darker and darker hue until in about a month it is dark brown and the black spots begin to appear. In some cases these spots, which are arranged in a line, disappear and the body is of a solid color. These black spots may or may not reappear. When full grown the slug is nearly 7 inches in length.

DEVELOPMENT.

The writer has found freshly deposited egg masses at all times from spring until fall. In a greenhouse or other structure which is heated during the cold months the females deposit their eggs the year round.

The incubation period varies with the temperature and moisture. In an atmosphere of from 60° to 70° F. the eggs hatch in about 28 days, but if the temperature is higher the young will appear in a shorter time.

The young slugs develop slowly, feeding very little in the younger stages. In 30 days they attain a length of about an inch. This growth, however, depends upon the abundance of food and upon the weather conditions. The slug is capable of living on very little food, but during such times growth is slow.

The exact time required by the animal to attain full growth is not known, but slugs held in captivity and reared from eggs made a growth of 2 inches in six months. These slugs were reared in a greenhouse and were supplied with an abundance of food.

HIBERNATION.

The spotted garden slug undoubtedly spends the winter below the frost line in the ground, in drain pipes, cellars, greenhouses, and pits, on well walls, and along foundations. The writer has never found any during the colder winter months in exposed places, such as under boards, or in any of the old haunts of summer. Slugs which were exposed to a temperature below freezing soon succumbed.

NATURAL ENEMIES.

Among the slug's few natural enemies is the common toad.

HOW TO ABATE THE SLUG NUISANCE.

ARSENICALS PARTIALLY EFFECTIVE.

Owing to its habit of feeding by night and concealing itself during the day, the spotted garden slug is very difficult to control. It will avoid food of a coarse nature.

The application of arsenicals to the plant is impractical, chiefly because attack is local and the creatures avoid most poisoned substances. The use of poisoned baits is not entirely satisfactory because of the slowness of the slug to change its diet unless this becomes necessary to prevent starvation. The methods of control to be used vary according to the location in which the slugs feed and the nature of the food plant. In mushroom beds it is not practical to employ a poisoned bait because the slug prefers fungi to all other foods.

Where large plants are being injured poisoned baits may be employed with fair results. For this purpose baked or boiled white potatoes sprinkled with white arsenic have been found effective. This bait should be placed so that one potato will be in about 2 square feet of the affected area. Inferior potatoes are quite as useful as sound ones, and large tubers or roots should be sliced.

CONTROL BY CLEAN METHODS.

Wherever this pest occurs cleanliness will accomplish much toward its riddance.

Slugs may be kept under control in the mushroom house, first, by a thorough cleaning and then by a careful examination of all the material taken into the house to make certain that no slugs or eggs are attached to it. Old boards and the edges of the compost pile may harbor eggs or young, and these should be examined carefully before they are carried into the house.

COLLECTING SLUGS AT NIGHT.

After slugs have become established in a greenhouse they should be sought out at night with a lantern or pocket flashlight. The slugs at this time may be found feeding or crawling about in search of food. At such times they can be easily collected and destroyed. In the daytime they may be traced to their retreats by the trail of slime which they leave behind. Loose boards and débris lying about should be turned over and examined for eggs and young slugs.

THE USE OF LIME AND SALT.

Lime is the standard remedy for slugs, and salt and soot are efficient.

In a mushroom house the slugs can be prevented from gaining access to mushrooms by a border about 2 inches wide of lime, salt, road dust, soot, or any cheap powder, placed around the edges of the beds. When the slug touches this substance it will wriggle into the material. This causes it to secrete slime copiously and soon it exhausts itself and dies.

In the greenhouse slugs are more difficult to control, because there is a wider range for their activities and their hiding places are more numerous and not readily located. Young seedling beds should be protected by a border of such substances as are recommended in the case of mushrooms. In the case of potted plants each pot should be taken out and examined before the border of repellent is placed around it, as such pots are among the favorite haunts of the young slugs.

TREATMENT IN THE FIELD.

When abundant in the field or garden the slug is even more difficult to control than in the mushroom house or greenhouse, and the only solution of the problem consists in thoroughly cleaning up the hiding places of the pest, around the edges of the garden, under old boards and stones, and in any place that is cool and moist. These places should then be sprinkled with lime, and where practicable lime should be applied directly to the area and plants on which the slugs are feeding. In time this will drive them away.

NEUFCHÂTEL AND CREAM CHEESE: FARM MANUFACTURE AND USE

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NEUFCHÂTEL CHEESE is named after the town of that name in northwestern France. Cream cheese is usually made from milk having about 6 per cent fat, while Neufchâtel is made from ordinary 4 per cent milk. Cream cheese is also marketed in a number of combinations or flavorings, a popular form containing pimienta peppers.

This group of soft cheeses can be made with little trouble and at small expense for equipment. Although now largely produced in factories, they can be manufactured at home for family use. Frequently also the surplus milk of a small dealer can be marketed advantageously as Neufchâtel, cream, or pimienta-cream cheese.

While these varieties of soft cheese are highly regarded, their real food value is often unappreciated. When served alone or in any one of a multitude of dishes they are palatable and appetizing as well as nourishing.

NEUFCHÂTEL AND CREAM CHEESE: FARM MANUFACTURE AND USE.

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CHARACTERISTICS OF THE NEUFCHÂTEL GROUP OF CHEESES.

CHEESES of the Neufchâtel group have been produced in the United States almost exclusively by a very few factories whose methods were not readily available to the public and whose extensive and high-priced equipment created the mistaken notion that it is not practicable to make these cheeses except upon a factory scale. The methods of manufacture of Neufchâtel and cream cheese and their modifications are, however, simple, and the equipment needed for making them in small quantities is not elaborate; therefore an excellent opportunity is offered to produce at low cost a fresh, wholesome, and attractive food for home use. Since Neufchâtel and cream cheese may be marketed upon a small scale, they often offer to dairymen an exceptional opportunity for the disposal of surplus milk.

The cheeses of this group are perishable, and their selling prices are somewhat higher, pound for pound, than the harder cheeses. They are coming more and more into common use, however, because, in addition to their rich flavor and high nutritive value, they may be used with other foods to form many appetizing dishes. When cheeses of this group are to be sent to market, special, though inexpensive, equipment is necessary in order to obtain the greatest efficiency of time and labor in molding them into marketable form.

An expenditure of from \$10 to \$25 will provide proper equipment for handling the cheese from several hundred pounds of milk. Such equipment should enable the dairyman to make and market cheese directly to the consumer at less cost and in fresher condition than that shipped from a more distant point. The fact that fresh cheese can be obtained readily will tend to increase its consumption.

THE MANUFACTURE OF NEUFCHÂTEL AND CREAM CHEESE.

In this bulletin the production of the Neufchâtel group of cheese is considered from two points of view, (1) for home consumption and (2) for marketing on a small scale.

QUALITY OF MILK.

The quality of milk is the first consideration in the production of good Neufchâtel or cream cheese. Milk which is sour or has undergone any abnormal fermentation should not be used. By the use of fresh, unripened milk without any perceptible change in the acidity, the normal fermentations which are necessary for cheese of high quality can be controlled. Milk for cheesemaking should not be allowed to absorb any odors or taints, and the garlic flavor, especially, should be guarded against.

CLEAN UTENSILS.

Cleanliness of utensils is another essential in producing cheese of high quality. The following system is advised in washing milk and cheese utensils:

1. After using, rinse with cold water.
2. Wash with hot water to which a washing powder has been added. Always use a brush.
3. Rinse in hot water at a temperature above 150° F.
4. Steam or immerse in boiling water for five minutes.
5. Do not dry the utensils with a cloth but place them in a clean place free from dust.

RIPENING THE MILK.

The cheese is made by allowing the acid and rennet, or other curdling agent, to act simultaneously upon the milk. If great care has been used in the production and subsequent handling of the milk, the cheese may be made by adding rennet and allowing the milk to sour normally. A rather rapid development of acid is most desirable, as this tends to eliminate undesirable flavors, hastens the making process, and prevents losses of the curd. The lack of uniformity in ripening often requires a more definite means of controlling the acid fermentation, which may be accomplished by the use of a "starter."

THE USE OF STARTERS.

A "starter" is a quantity of milk that has soured and which contains large numbers of acid-forming bacteria. If the cheese is made in small quantities for home consumption, a starter is probably not advisable. The advantages of a starter over the natural souring are:

1. It hastens the coagulation of the milk.
2. It suppresses undesirable fermentations that may cause excessive losses of fat and curd.
3. It aids in suppressing undesirable flavors and produces more uniform cheese.

A starter of *Bacillus bulgaricus* may be used instead of the ordinary lactic-acid starter, but it is recommended only when there is a special demand for it.

STANDARDIZING THE MILK.

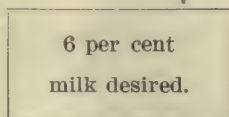
In making cream cheese for the market, milk testing about 6 per cent butterfat is most satisfactory. With 4 per cent milk available, if one-third of the quantity is run through a cream separator and the cream added to the remaining two-thirds, milk testing approximately 6 per cent is obtained. If the milk tests only 3 per cent it will be necessary to separate one-half of the quantity and add the cream to the remaining half. This method gives satisfactory results for home manufacture, but for more extensive operations it is advisable to use a Babcock tester in order to standardize the milk accurately.

The following diagram illustrates an easy method of determining the proportions of milk and cream of different per cent of fat needed to make up 6 per cent milk:

Cream and milk on hand.

34 per cent cream.

4 per cent milk.



Proportions to be used.

2 parts cream.

28 parts milk.

The desired per cent of fat in the milk, in this case 6, is placed in the center of the square. At the upper left-hand corner the per cent of fat in the available cream is placed, in this instance 34. Immediately below, in the lower left-hand corner, the per cent of fat in the available milk is placed, which in the instance cited is 4. Next subtract diagonally across the square the smaller from the larger numbers and place the differences in the upper and lower right-hand corners respectively. In the upper right-hand corner 2 represents the number of parts of 34 per cent cream, and in the lower right-hand corner 28 represents the number of parts of 4 per cent milk necessary to make 6 per cent milk. If it is desired to make up a definite quantity of 6 per cent milk, for example, 60 pounds, the pro-

cedure is as follows: 2 added to 28 makes a total of 30 parts of 6 per cent milk. The quantity of 34 per cent cream necessary is $\frac{2}{30} \times 60$, or 4 pounds, while the quantity of 4 per cent milk is $\frac{28}{30} \times 60$, or 56 pounds.

PASTEURIZATION.

It is not always practicable to pasteurize the milk to make cheese for home use, but if the cheese is to be marketed it is very desirable to do so. When milk is pasteurized for cheesemaking it becomes absolutely essential to use a "starter" to obtain uniform results. It is advisable, also, to use the milk as soon as possible after pasteurization. Ordinarily, pasteurization is accomplished by heating the milk in a pail, can, or vat to a temperature of 145° F., and holding at that temperature for 30 minutes, after which it should be quickly cooled to 80° F. before adding the starter for ripening. The advantages of pasteurization are as follows:

1. It destroys disease-producing organisms.
2. It tends to reduce losses and increase the yield.
3. It aids in eliminating undesirable flavors.
4. Quality of cheese is more nearly uniform from day to day.

MAKING THE CHEESE.

The process described is identical for Neufchâtel and cream cheese, except for a few minor differences which will be mentioned.

Setting.—Unless otherwise noted, 30 pounds, or about 3½ gallons of milk, is the unit used in these directions; that quantity can be handled conveniently in a shotgun can. For smaller quantities any enameled or heavily tinned pail is satisfactory.

If a starter is added, it is advisable to use a quantity equal to 1 or 1½ per cent of the milk; while smaller quantities may be used, the proportions suggested are usually the most satisfactory.

Neufchâtel is made from ordinary milk, while the cream cheese requires milk containing about 6 per cent of butterfat. Milk for Neufchâtel is warmed to 80° F., and one-half pint of starter is added and thoroughly stirred in with a long-handled spoon or milk agitator. Then 8 or 10 drops of commercial liquid rennet, diluted in half a cupful of cold water, is added to the mixture, thoroughly stirred, and the can of milk set away to coagulate at 80° F. Powdered pepsin, which is cheaper than rennet, may be used instead, in which case a quantity equal to one-half of a medium-sized pea, dissolved in a cupful of cold water, is used. Fresh junket tablets also may be substituted for rennet. One tablet is dissolved in 10 tablespoonfuls of cold water and 3 tablespoonfuls of the solution used. For cream cheese a slightly larger quantity of the curdling agent is desirable.

For cream cheese the milk is warmed to 83° F., the process being the same in other respects. When starter is not used in making either kind of cheese, the process is unchanged except that after thoroughly stirring the milk it is set away, at the temperature described, for several hours before the rennet or other curdling agent is added.

After the milk has been set away to coagulate it should be kept as nearly as possible at the same temperature. Under normal conditions, after about 15 or 18 hours, about one-half inch of whey collects upon the surface of the curd or coagulum; on the top of the whey a scum of fine white curd particles sometimes collects. This formation of whey indicates a normal fermentation. When the fermentation is abnormal, the coagulum is more or less convex, puffed, or inflated, and there is little, if any, whey on the surface.

A gassy fermentation of the curd does not necessarily render a cheese unfit for consumption; but for best results, both as to flavor and economy in handling, that condition should be prevented.

Under ideal conditions the milk usually begins to coagulate in the course of a few hours, but is allowed to stand undisturbed for from 15 to 18 hours. It is advisable to set it so that the curdling occurs during the night, and if the cans are not provided with covers they should be covered with a close-meshed cheesecloth in order to exclude dirt.

Draining.—After the setting period, when whey has collected upon the surface of the coagulum, or when the milk is firmly clabbered, the contents of the can or pail are poured upon a strong drain cloth. (See fig. 1.) The can may be shaken slightly before pouring, in order



FIG. 1.—Pouring the curd into the drain cloth.

to loosen any curd which has a tendency to adhere to the sides or bottom. Unbleached cotton sheeting, which can be obtained in yard widths, has proved to be the most satisfactory material for drain cloths. For a small-scale operation the cloth may be thrown over a pail, can, or wash boiler and the ends tied securely about the draining receptacle. The curd or coagulum should remain undisturbed in the cloth for 3 or 4 hours, after which it should be worked toward the center of the cloth in order to hasten the draining and get it in better

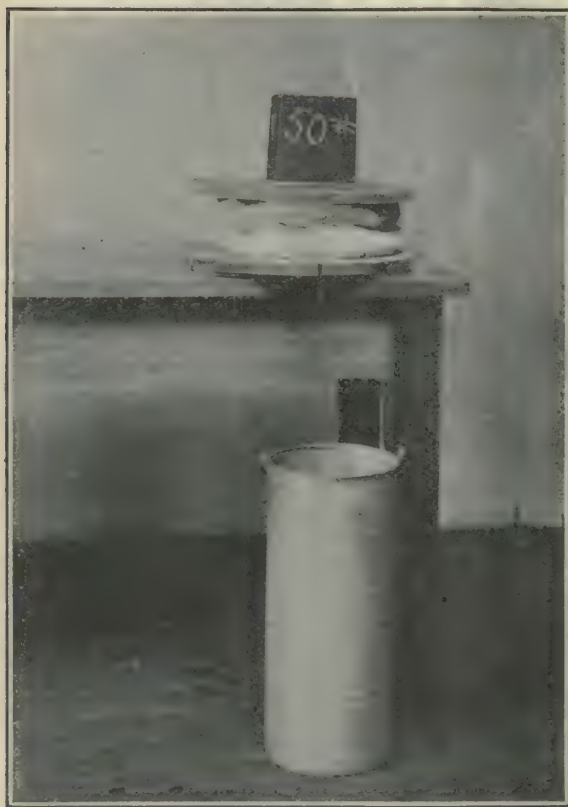


FIG. 2.—An improvised cheese press.

condition for handling. Drainage is allowed to continue until most of the visible whey has escaped and the curd appears rather dry as compared with its former mushy condition. Then the four corners of the cloth should be drawn diagonally across and tied. For home consumption, and especially when it is not cooled, the curd should be allowed to drain for a longer time before pressing.

Cooling the curd.—

While the cooling of the curd is very desirable, it is not absolutely necessary. The object of cool-

ing is to facilitate the more rapid expulsion of whey during pressing. Cooling also seems to harden the curd so that it does not pass so readily into the meshes of the drain cloth and thereby interfere with and retard the expulsion of the whey. The bags of curd are placed on ice, or cracked ice is placed about them and left for a few hours.

Pressing.—After cooling, several bags of the curd are piled together between two boards and a weight of 50 pounds placed on top. (See fig. 2.) Frequent rearrangement of the bags will hasten the process. After this weight has been left on the cheese overnight, the curd should be in flat cakes. For Neufchâtel it is preferable

to press the curd from 30 pounds of milk until the pressed curd weighs $4\frac{1}{2}$ pounds, while for cream cheese it should weigh about $5\frac{1}{2}$ pounds. Special care should be taken in determining the yield of cheese in order to obtain a uniform quality from day to day, which can be done by weighing the curd. The manner and length of time of pressing determines, in a large measure, the texture of the cheese. By using a screw press the curd may become too dry and gummy, but under ordinary conditions there is little danger if improvised equipment is used. (See fig. 3.)

Working and salting.—After having been properly pressed the cakes of curd are salted and worked with a potato masher or butterworker, or run through a food chopper to produce a smooth, buttery consistence.

Fine, dry salt is sprinkled over the curd at the rate of about 2 or $2\frac{1}{2}$ ounces to 10 pounds of curd; or about two level tablespoonfuls to the curd from 30 pounds of milk. (See fig. 4.) The

quantity of salt may be varied to suit the individual taste; the quantities recommended, however, usually give the best satisfaction. If the curd is worked with a potato masher the addition of salt aids in obtaining the proper smoothness of the cheese.

When cheese is made for home consumption it may be placed in a glazed crock or porcelain dish immediately after salting and held

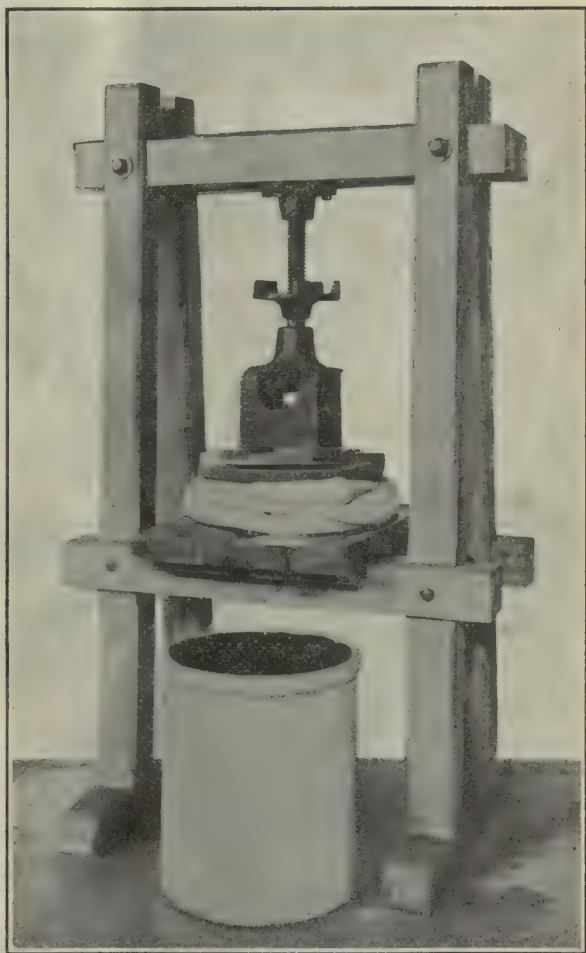


FIG. 3.—A screw press.

at a temperature as near 50° F. as possible until consumed. Under favorable conditions it will keep in good condition for from 6 to 12 days. When cheese is kept a few days at a temperature of 60° to 70° F., it will become disagreeably sour. It is most palatable



FIG. 4.—Salting and working the cheese.

immediately after it is made, for then it is fresh, soft, and sweet. When very cold, or after having been kept for some time, it does not have so fine a flavor.

Combinations with Neufchâtel and cream cheeses.—Finely chopped pimienta peppers may be mixed with either Neufchâtel or cream

cheese at the time of salting. Such cheese has a mild though pronounced flavor and is very popular for sandwiches and salads. The pimientos seem to have a certain preservative effect and tend to cover up "off flavors" that may develop. About 1 pound of the chopped pimientos is added to 12 pounds of cheese, or about one-half pound for the cheese from 30 pounds of milk.

While there are numerous other cream-cheese combinations, there are two that are worthy of especial note—olive-pimiento cream and Roquefort cream cheese. Both of these flavoring ingredients should be added at the rate of 1 part to 10 parts of cream cheese. When Roquefort cheese is uniformly incorporated with cream cheese it gives to the combination a rich and pleasing flavor very similar to Roquefort cheese, though milder.

Molding.—Cheese for home consumption need not be molded. When marketed a special device is necessary in order to shape the cheese into a commercial package. Neufchâtel, cream, and pimiento cheeses require a special style of package. While there are numerous devices for molding, many of them are not suited for meeting market demands. As a result of considerable experimenting the attachments described below were devised to fit the ordinary food chopper and proved to be very satisfactory for handling the several kinds of cheese.

For molding small quantities of cheese the following equipment is desirable: (See figs. 8 to 12.)

1. A food chopper.
2. A hopper.
3. Two molding attachments for chopper.
4. A cheese conveyor.
5. A cheese cutter.

When used for molding, both the knives and the plate should be removed from the chopper; otherwise the cheese will go through with great difficulty. The cheese hopper is a boxlike arrangement clamped to the top of the food chopper to prevent the scattering of particles of cheese upon the worktable. The cheese is poured into the hopper at short intervals, since it is not advisable to keep the hopper more than half full, or the feed screw will not force the cheese so readily through the hopper. If the hopper is full the cheese may become too "gummy" and will not only be difficult to force through the chopper, but will adhere to the long-handled spoon used to push the lumps of curd into the machine. It is advisable to use a spoon in order to keep one corner of the hopper free of the cheese and, by allowing the escape of air, facilitate the grinding of the cheese.

The lips of the molding attachment are fastened to the chopper by means of a ring. The attachment for molding Neufchâtel cheese is cylindrical and is about $1\frac{1}{2}$ inches in diameter at its delivery end.

The cheese, forced through this attachment, comes out in the form of a roll or cylinder.

Pimiento cheese is forced into a special glass jar smaller than a jelly glass or a paraffined wood-fiber container held horizontally over the end of the Neufchâtel attachment so that the cheese reaches the end of the container and flattens out without difficulty. (See fig. 5.) If the pimiento cheese is to be used in a short time, the wood-fiber containers are especially recommended, as they are less expensive than glass jars. If the cheese is marketed directly to the consumer, the glass jars may be returned and used again.



FIG. 5.—Filling jars with pimiento-cream cheese.

The attachment for cream cheese is rectangular at its delivery end. By its use the cheese may be molded into smooth, ribbonlike bands which, as in the case of Neufchâtel cheese, may be cut with a wire into pieces of the desired size.

The cheese is delivered from the attachment on a canvas conveyer, supported by rollers, which turn with sufficient friction to cause the plastic curd to be firmly pressed together as the cheese is automatically pushed forward. (See fig. 6.) The first cheese that passes through the attachment often "frills"; that is, it presents an irregular surface, but later the difficulty becomes less marked, and the

cheese comes out with a surface well defined and smooth. "Frilling" occurs more often in molding cream cheese than in Neufchâtel.

Cutting the cheese.—Cream cheese and Neufchâtel cheese may be cut into cakes of the desired size by means of fine wires drawn over a rectangular-shaped framework. (See fig. 11.) The use of this simple equipment makes it possible to cut half a dozen cheeses simultaneously and prevents delay, so that one person may do the grinding while another cuts and wraps the cakes.

Wrapping the cheese.—After cutting the cakes they are slowly carried along by the carrier and eventually fall upon a flat form upon which tin-foil wrapping papers are laid. These papers may be

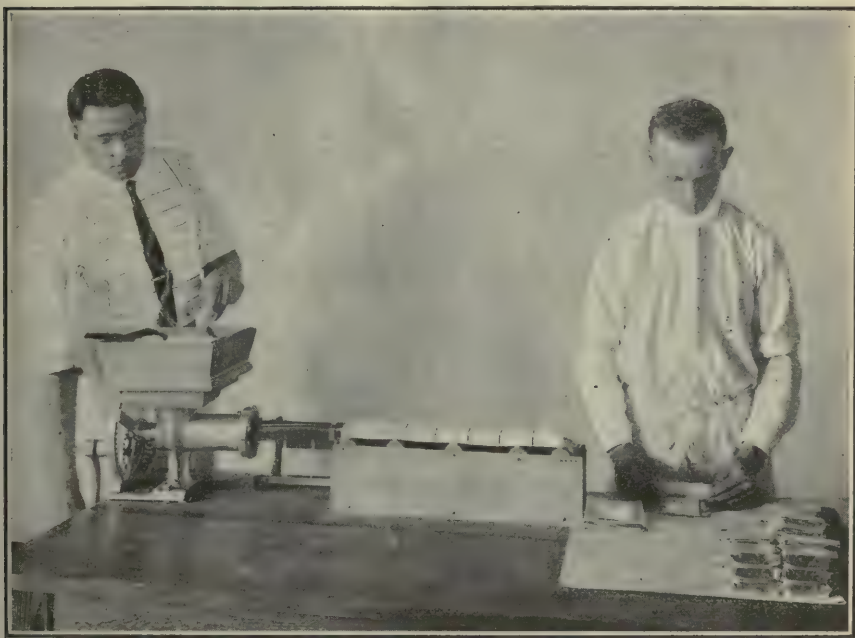


FIG. 6.—Molding and wrapping cream cheese.

held in place by a cleat or clamp. In many cases it is more convenient to take the cheese directly from the carrier, but when the person who does the wrapping is kept very busy the platform may serve as a place where several cakes may accumulate, thus allowing the grinding operations to be continued. While one person is engaged in filling the hopper and molding the cheese another is kept busy cutting and wrapping. In wrapping, the cheese is placed in the center of the paper, each side of the paper folded over, and the ends turned down, to cover the cheese completely. (See fig. 10.)

Yield.—One hundred pounds of milk containing 4 per cent fat should yield from 14 to 16 pounds of Neufchâtel cheese, while 6 per cent milk should give an average yield of from 17 to 19 pounds

of cream cheese. With milk testing less than the above, a smaller yield and a lower grade of cheese will be obtained. Although there may be slight seasonal fluctuations in the solids of milk, yet for the most part the yield of cheese, other conditions being equal, is almost directly proportional to the per cent of fat. There may be variations in yield of cheese, however, due to mechanical factors, such as longer pressing.

Neufchâtel cheese is sometimes made from skim milk, in which case it is used for cooking and baking purposes. Commercially, there are other grades of Neufchâtel made from one-half or two-thirds skim milk. Such cheeses are labeled as made from "partially skimmed milk" or "skimmed milk" as the case may be.



FIG. 7.—Types of packages.

Packages.—Tin-foil or aluminum-foil wrapping paper which has a parchment paper inside is generally used in wrapping cream and Neufchâtel cheeses, since it gives each package a bright, uniform, and attractive appearance. (See fig. 7.) Great care should be taken to wrap each cake neatly and securely in order to exclude the air as much as possible. Any "frilling" or other irregularities may be corrected by drawing the foil tightly about the cheese. Careful and skillful wrapping tends to increase the length of time the cheese is salable. The yellow or amber-colored mold which often spreads over the cheese should be prevented as much as possible, not because it may render the food harmful or poisonous, but because it causes deterioration and renders the cheese less appetizing.

The standard Neufchâtel package is cylindrical, about $1\frac{1}{2}$ inches in diameter by $2\frac{1}{2}$ inches long, and weighs about $2\frac{1}{2}$ ounces net.

Standard packages of cream cheese are about 3 by 2 inches and 1 inch thick, and have a net weight of about 3 ounces. The pimiento cheese is marketed in 3 or 4 ounce glass jars, each packed full and covered with a disk of paraffined paper and screw cap.

COST OF MANUFACTURE.

When made upon a small scale the cost of the various items of making these kinds of cheese for market purposes is difficult to ascertain. The cost of manufacturing them on a farm scale would probably be quite different from the cost of manufacturing them on a factory scale. The figures given are based upon the use of 200 pounds of 4 per cent milk, valued at \$2.40 a hundredweight, which is made into cheese twice weekly with equipment costing about \$25. The cost of the equipment depends, of course, upon that already available and that which may readily be improvised. Under average conditions the approximate cost of the various items of expense involved in making the three kinds of cheese is enumerated as follows:

COST OF MAKING CREAM CHEESE.

With 200 pounds of 4 per cent milk a dairyman should be able to make 24 pounds of cream cheese, and with the skim milk 12 pounds of cottage cheese in addition. At present cream cheese is marketed in 3-ounce packages. Figuring conservatively, the yield from 200 pounds of milk, then, would be about 120 packages of cream cheese and 12 pounds of cottage cheese. Assigning a value of 6 cents a pound for the latter, and subtracting the amount received for it, the cost of the milk used for cream cheese would be reduced from \$4.80 to \$4.08. The cost of milk for each package of cream cheese, then, would be \$0.034.

The cost of special equipment necessary for handling the cheese may be proportioned as follows:

1 food chopper.....	\$8. 50
6 shotgun cans.....	5. 10
6 drain racks.....	4. 50
2 molding attachments.....	2. 00
1 carrier.....	1. 25
1 thermometer.....	. 60
1 hopper.....	. 50
1 cheese cutter.....	. 50
6 yards of cloth for draining.....	. 75
1 pail.....	. 85
1 agitator or stirrer.....	. 25
2 spoons, long-handled.....	. 20

 25. 00

A good food chopper should last 10 years, a drain rack 5 years, and a shotgun can about 3 years. Figuring a yearly depreciation of about 20 per cent, the depreciation charges would be \$5. The interest at 6 per cent on the investment would be \$1.50, and the interest and depreciation charges per cheese would be $1/12000$ of \$6.50, or \$0.00054.

The labor would require half an hour to pasteurize the milk, about $1\frac{1}{2}$ hours to make the cheese, and another half hour to mold it, or about $2\frac{1}{2}$ hours, actual time for the various operations. However, while in pressing it would require but a few minutes to handle the cheese, the entire pressing operations would extend over several hours. It is assumed, therefore, that the time not used in working with the cheese could be utilized in some other manner. The total labor charge would be 50 cents, figuring labor at 20 cents an hour. The labor charges would then be $1/120 \times 50$, or \$0.00416 for each cheese.

Figuring the cost of pasteurization and separation as 1 cent a gallon, the charge for each cheese would be \$0.00192. It would require about 50 pounds of ice for the 24 pounds of cheese, which would make the ice cost about \$0.00016. Figuring the rennet at \$10 a gallon and the salt at 1 cent a pound, the charge would be \$0.00005, and \$0.004 for tin foil at 90 cents a pound:

Milk.....	\$0. 03400
Interest and depreciation.....	. 00054
Labor.....	. 00416
Pasteurization and separation.....	. 00192
Ice.....	. 00016
Salt and rennet.....	. 00005
Tin-foil wrapping paper.....	. 00400
Per cheese	0. 04483

COST OF MAKING PIMIENTO-CREAM CHEESE.

Pimiento-cream cheese is made practically the same as cream cheese, with the single exception that pimiento peppers are added. The cheese is usually marketed in 4-ounce glass jars, which may be obtained in gross lots for about 2 cents each. Pimiento peppers cost about 40 cents a pound and are added to the cheese at the rate of 1 pound to from 10 to 20 pounds of curd, as some people prefer a higher proportion of the peppers. The figures given are on the basis of 1 pound of peppers to 12 pounds of cheese. The labor charge will be somewhat greater for pimiento cheese than for cream cheese; the labor charges are figured at $3\frac{1}{2}$ hours instead of $2\frac{1}{2}$, as in the case of cream cheese. There would then be a yield of 26 pounds of cheese, costing \$4.08. When pimiento cheese is produced under the conditions outlined the cost for each jar may be summarized as follows:

Milk	\$0.03457
Interest and depreciation	.00055
Labor	.00593
Pasteurization and separation	.00196
Ice	.00016
Salt and rennet	.00005
Glass jar	.02000
Peppers	.00666
Per jar	.06988

COST OF MAKING NEUFCHÂTEL CHEESE.

Figuring a yield of 15 pounds of cheese per 100 pounds of milk and each package weighing $2\frac{1}{2}$ ounces, the cost of making one Neufchâtel cheese may be summarized as follows:

Milk	\$0.02500
Depreciation and interest	.00033
Ice	.00013
Labor	.00260
Pasteurization	.00120
Salt and rennet	.00005
Tin-foil wrapping paper	.00400
Per cheese	.03331

MARKETING.

Neufchâtel, cream, and pimientto-cream cheeses are sold by the box. The wholesale price of a cheese is usually 2 or 3 cents less than the retail price. Cream cheese retails for about 15 cents a package, Neufchâtel for 7 cents, and pimientto cream at 15 cents a jar.

RETURNS FROM 100 POUNDS OF MILK.

Upon the basis of the calculated cost of manufacturing and at current prices for the cheese, the following returns should be obtained per 100 pounds of 4 per cent milk, viz, for cream cheese \$9, for Neufchâtel \$8.40, and for pimientto cream \$8.85. After subtracting the estimated cost of making the cheese from 4 per cent milk, valued at \$2.40 a hundredweight, there should be a net profit of \$6.14 for cream cheese, \$6.22 for Neufchâtel, and \$4.45 for pimientto cream. Rent and cost of marketing are not considered.

POSSIBILITIES.

The desirability of making these varieties of cheese upon a small scale and successfully marketing them depends upon the skill of the maker and his ability to obtain a direct and ready market for his product. When cheese is made and delivered once or twice a week, a dairyman is in far better position to serve the public by selling a perfectly fresh product than the larger manufacturers, working at a

distance, who are obliged to dispose of their cheese several days after it is made, and who must pay the additional expense of boxing and shipping. If the cheese is marketed directly upon a small scale it is not necessary to put it into the flat boxes, as is the case if it is handled commercially. The cheeses may be disposed of satisfactorily by placing them in one large box and piling one cheese upon another. When cheese of this type is delivered upon a milk route the use of a special box provided with two compartments, one for ice and the other for cheese, is advisable during the warm periods of the year. Pimiento-cream cheese, because of its keeping quality, is particularly adaptable to small-scale operations. When sold in glass jars it is sold as readily as the product of the larger manufacturers. With a direct outlet, arrangements may be made to use the jars again and thereby reduce the cost of marketing.

When suitably situated it should be practicable for many dairymen to supply cheese to a neighboring town at good prices for their milk and extra trouble. It should be especially feasible for the milk dealer to dispose of his surplus milk in the form of cheese; in fact, in some cases for some of these kinds of soft cheese he would receive as much as or more than for the milk. By beginning in a small way the milk dealer should be able to develop a trade in fancy cheeses, such as cottage, Neufchâtel, cream, and pimiento cream, and by selling direct to the consumer he could compete successfully with larger manufacturers.

KEEPING QUALITIES OF THE CHEESE.

When wrapped in foil and put into a cold place immediately after making, cream and Neufchâtel cheeses should keep from 6 to 12 days without developing objectionable flavors; usually cream cheese seems to keep somewhat better than Neufchâtel. If pimiento-cream cheese is placed in the customary jars and held at 50° F. or below, it should be still palatable at the end of a month. These products develop a sourish taste rather quickly when held at a high temperature. The temperature, therefore, is by far the most important factor concerned in regulating the keeping qualities of the cheese. There may be considerable variation in both the salt and water content of the cheese without causing much deterioration.

EQUIPMENT FOR MAKING NEUFCHÂTEL AND CREAM CHEESES.

Little equipment is needed for making these cheeses for home consumption, and many satisfactory substitutes may be found for that mentioned. When the cheese is marketed on a large scale a greater outlay is desirable in order to handle it efficiently.

Floating dairy thermometer.—The use of a reliable and accurate thermometer is imperative if uniform results are to be obtained. A

thermometer of this kind is not expensive, and when not in use should always be kept in the case.

Starter bottles.—Pint milk bottles, which may be covered with glass tumblers, are needed for holding the starter, although the size of the containers depends, of course, upon the quantity of cheese made. Pint fruit jars also can be used, and may be covered with bowls.

Shotgun cans.—These cans are usually 9 inches in diameter, 20 inches high, and hold about 4 gallons of milk. For work on a small scale a 10-quart, heavily tinned or enameled pail may be used satisfactorily.

Rennet and pepsin.—Commercial liquid rennet and powdered pepsin have been found to be satisfactory curdling agents. Fresh junket tablets also produce good results.

Milk agitator.—A stirrer is desirable to cause a uniform distribution of rennet or starter and to aid in preventing a too rapid rising of the cream. A long-handled spoon may be used if only a small quantity of cheese is made.

Draining rack.—The rack shown in figure 1 is rectangular, 13 inches wide, 36 inches long, and 10 inches deep. The corner posts extend $1\frac{1}{2}$ inches beyond the strips at top and bottom, with the top rounded, so that a ring may fit over them. The bottom slats fit loosely into notches and are removable for washing purposes. The materials required are 4 corner posts $1\frac{1}{2}$ by $1\frac{1}{2}$ by 10 inches, 9 strips 1 by $\frac{3}{8}$ by 36 inches, and 6 strips 1 by $\frac{3}{8}$ by $12\frac{1}{4}$ inches, notched to receive bottom slats, all made of pine. A cloth is fastened upon each frame and the contents of one can poured upon each cloth. For small-scale operations an orange crate or a boiler or pail may serve the same purpose.

Drain cloth.—Unbleached cotton sheeting is recommended for this purpose. A fine-meshed cloth gives strength and aids in preventing losses of fat and casein. The size of the cloth depends upon the nature of the draining rack. Each cloth should be 45 inches long and a yard wide, with the ends hemmed. After use each should be quickly and carefully washed and dried in order to increase the period of its usefulness.

Press.—If a screw press is available, its use is to be recommended. A 50 or 60 pound weight, such as a can of water or bucket of stones, left upon the curd overnight usually proves to be satisfactory. (See figs. 2 and 3.)

Curd worker.—For small-scale operations a bread mixer or a potato masher may be used to give the curd proper consistence and to incorporate the salt. When working on a larger scale a butter-worker or food chopper will serve the same purpose.

Food chopper.—A food chopper with special attachments and a hopper are essential for molding the cheese into the desired forms. Depending upon the quantity of cheese handled, satisfactory food choppers may be obtained in three sizes, costing about \$2, \$5, and \$8.50. (See fig. 8.) The smaller machines may be used in handling Neufchâtel and pimientto-cream cheese, but cream cheese requires the large size for making the customary flat packages. The large machine is to be recommended if the weekly output of cheese amounts to a few hundred pounds, although the medium-sized machine would probably do the work as effectively, only more slowly and with more labor.

Cheese hopper.—The hopper consists of an open box 3 inches deep, made of maple, with sides sloping outward about half an inch. The

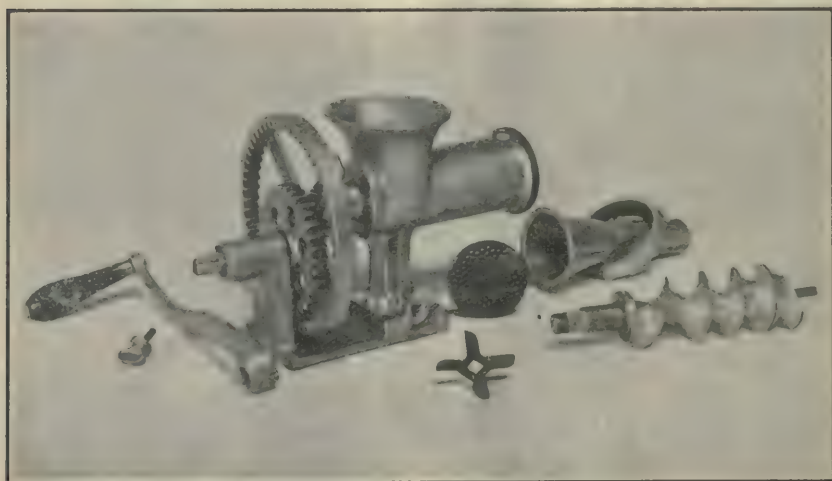


FIG. 8.—Grinding and molding equipment.

box has a hole in the bottom $3\frac{1}{8}$ by $3\frac{5}{8}$ inches. To the bottom of the box a board five-eighths of an inch thick is screwed, which has a hole corresponding to that of the box. The hopper is fastened to the food chopper by means of a beveled strip of wood and button, as indicated in figure 9. The base of the box will probably have to be grooved in order to allow the wheel to turn without friction. The materials required are (1) two quadrangular-shaped pieces of wood 3 inches high, five-eighths of an inch in thickness, and whose tops measure $9\frac{3}{8}$ inches and the bottoms 8 inches; (2) two pieces of similar shape, except that the tops measure $11\frac{1}{2}$ inches and the bases $10\frac{1}{4}$ inches; (3) one piece $10\frac{7}{8}$ inches long, $10\frac{1}{8}$ inches wide, and three-quarters of an inch thick; (4) one piece $9\frac{3}{8}$ inches long, 7 inches wide, and three-quarters of an inch thick; and (5) one piece 7 inches long, $4\frac{3}{8}$ inches wide, and five-eighths of an inch thick.

Neufchâtel attachment.—The attachment for molding Neufchâtel and pimienta-cream cheeses consists of a tin form having a conical shape with a tube attached. The cone has a $2\frac{1}{4}$ -inch base which gradually tapers down to a tube whose diameter is $1\frac{1}{2}$ inches. (See fig. 10.) The distance from the base of the cone to the tube attached is $3\frac{1}{4}$ inches; the tube is about 5 inches long. A vertical lip about one-quarter of an inch across makes it possible to connect the tube to the food chopper; the attachment fits into the ring of the chopper.

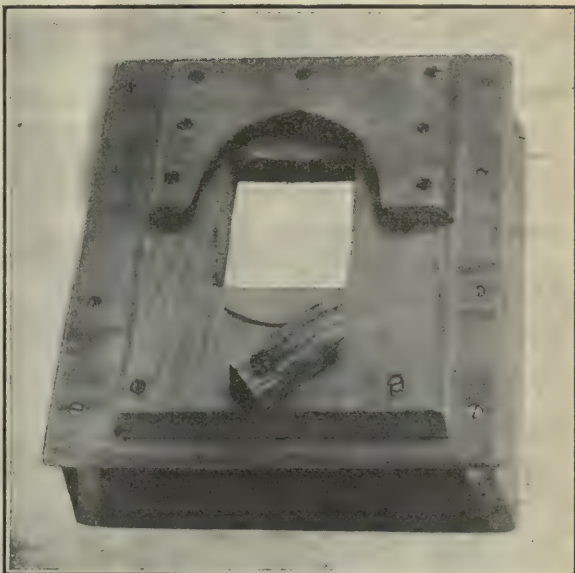


FIG. 9.—Under view of cheese hopper, showing method of attachment.

Cream-cheese attachment.—The cream-cheese attachment consists of a ring to which a rectangular-shaped molding tube is soldered. (See fig. 10.) The base of the tube is $2\frac{1}{8}$ inches wide and fifteen-



FIG. 10.—Molding attachments for Neufchâtel and cream cheese.

sixteenths of an inch thick. The delivery end of the tube, which is $2\frac{1}{8}$ inches wide and three-quarters of an inch thick, is cut back one-third of an inch at each corner and V-shaped pieces of tin removed.

The lips of the tube are then drawn together until there is about one-sixteenth of an inch of free space at each corner.

Belt conveyer.—The belt conveyer used in removing the cheese as it leaves the attachment is shown in fig. 11. It is a rectangular-shaped box, 20 inches long, 6 inches wide, and $4\frac{3}{4}$ inches deep, with the ends and top removed. Five bearings fit into the notches on one side and holes on the other side in two strips of iron fastened to the upper edges of the two open ends of the box. A $3\frac{1}{2}$ -inch canvas belt runs snugly though not tightly upon the rollers. The materials required are two pieces of maple $4\frac{3}{4}$ inches wide, one-half inch thick and 20 inches long; four oak rollers $4\frac{3}{8}$ inches long and $1\frac{3}{4}$ inches in diameter; one oak roller $4\frac{3}{8}$ inches long and $1\frac{1}{2}$ inches in diameter. The rollers have a one-sixteenth-inch clearance and are beveled one-eighth of an inch from bearing to outer face. In addition, two 20-inch strips

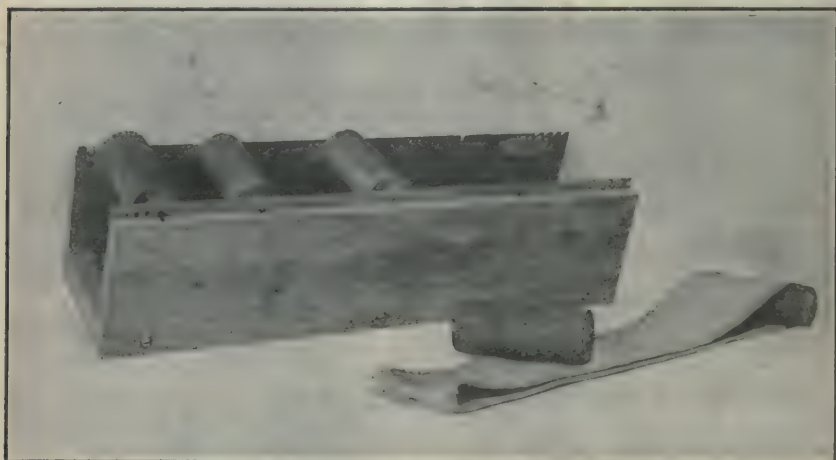


FIG. 11.—Belt conveyer.

of galvanized iron 1 inch wide and one-eighth of an inch thick are needed. In both ends of one of these strips of iron there are four outward-slanting notches which are one-half inch deep and one-eighth inch wide, and evenly spaced between the ends there are three additional vertical notches of the same size. There are 11 one-eighth-inch holes in the second iron strip, corresponding to, parallel with, and of the same height as the bottom of the notches of the first strip. The boards and strips of iron are joined together by means of screws.

Cheese cutter.—A cheese cutter consists of a rectangular framework of poplar over which 7 fine wires are drawn. (See fig. 12.) The wires are fastened by means of iron pegs or screws to the outer edge of two half-inch strips 15 inches long. The strips are 5 inches apart, parallel, and are supported by 3 vertical pieces of wood 5 inches long, 3 inches wide, and one-half inch thick. Each of these

supports is hollowed out in order to give plenty of space for cutting the cheese. The vertical supports are held in place by means of a single flat strip $13\frac{3}{4}$ inches long, seven-eighths inch wide, and one-quarter inch thick. The wires are placed $2\frac{1}{2}$ inches apart and the supports $6\frac{3}{4}$ inches apart. All connections are made with 1-inch screws.

Tin-foil paper.—Tin foil covered with parchment paper is generally used to wrap the cheese (cream or Neufchâtel), although of late aluminum foil has been used quite extensively. The dimensions of the foil are $4\frac{1}{2}$ by 6 inches, and it is purchased by the pound.

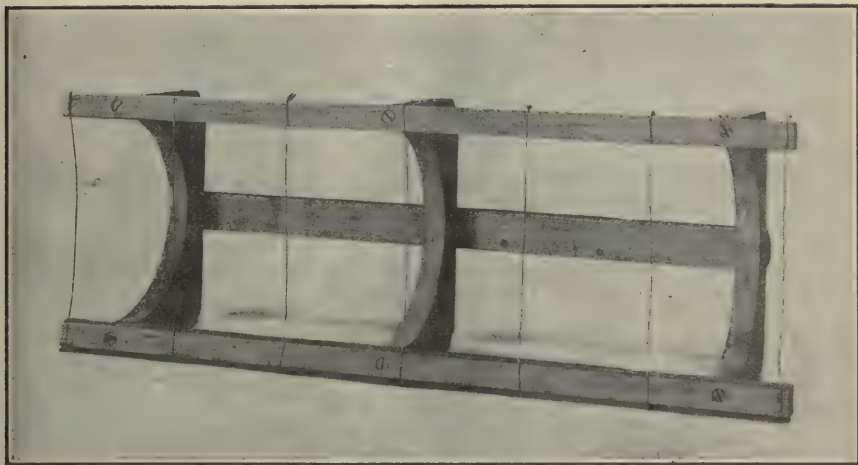


FIG. 12.—Cheese cutter.

SUMMARY OF DIRECTIONS.

The following outline for making the Neufchâtel group of cheeses is based on 30 pounds or $3\frac{1}{2}$ gallons of milk.

Except as noted, the process is the same for Neufchâtel as for cream cheese. For Neufchâtel cheese use whole milk that tests 4 per cent, and for cream cheese use milk standardized to 6 per cent.

If it is desired to pasteurize, heat the milk to 145° F., hold at that temperature for 30 minutes, then cool to 80° F. for Neufchâtel and 83° F. for cream cheese. If the milk is pasteurized, a starter must be added.

Add half a pint of a good starter or clean-flavored sour milk and stir well. Rennet is then added at the rate of one-third of a cubic centimeter (about eight drops), diluted in a cup of cold water, stirred in thoroughly, and the milk set aside to curdle. In place of rennet, powdered pepsin (one-half the size of a pea) dissolved in a cup of cold water, or one-third of a junket tablet dissolved in a like quantity of water, may be added. In making cream cheese it is ad-

visible to use a very slightly larger quantity of the curdling agent than for Neufchâtel.

If the milk is not pasteurized, warm or cool it to the temperatures mentioned above, add starter and rennet as described, and set away to curdle.

If starter is not used, the milk is set away for several hours, at the temperature described, before the rennet or other curdling agent is added. After thoroughly stirring, the milk is set away at the same temperature to curdle. In either process the time necessary for proper curdling is from 16 to 18 hours. It is often convenient to set the milk to curdle overnight.

Pour the coagulum or curdled milk upon the drain cloth and allow it to drain from 2 to 4 hours, or until practically no whey drips from the cloth and the curd is comparatively dry.

Scrape the curd toward the center of the cloth and tie the diagonal corners of the cloth together to facilitate handling.

If ice is available place the bag or curd in crushed ice and leave it for 3 hours or longer. If ice is not available allow the curd to drain an extra hour or more.

Place the bag of curd between two clean boards, put a 50-pound weight upon it, and let it stand. Pressing should cease when there is a yield of about $4\frac{1}{2}$ pounds of Neufchâtel or about $5\frac{1}{2}$ pounds of cream cheese. This will take about 6 or 8 hours. If a cider or other screw press is available the time required for pressing is about $1\frac{1}{2}$ hours.

Remove the curd from the cloth into a pail, sprinkle two level tablespoonfuls of fine salt over the curd, and thoroughly mix with a potato masher until it has a smooth, buttery consistence. Running the cheese through a food chopper or working it with a butterworker produces the same result.

Place the cheese in a crock or enameled dish until ready for use.

Mold the cheese into commercial packages by means of the food chopper, special attachment, and cheese cutter.

Wrap in tin foil or aluminum foil, or pack in glass jars.

Keep the cheese at a temperature of 50° F. or below until consumed. At that temperature Neufchâtel and cream cheese should keep from 6 to 12 days, and pimiento-cream cheese should keep nearly a month.

THE USE OF NEUFCHÂTEL AND CREAM CHEESE IN THE DIET.

In nutritive value these cheeses compare favorably with other staple foods, especially meat. They are easily digested when taken in moderate quantities and in combinations with other foods, and, being rich in protein and fat, they easily replace such foods as meat, fish, and eggs. There are many foods with which they combine to

form appetizing and attractive dishes that are easily and quickly prepared. These cheeses may be used in a greater number of ways than other varieties because they are soft in texture, blend well with most foods, and are rich in protein and fat. Perhaps the most desirable ways to serve them are in the forms of salads, sandwiches, and similar dishes.

The Office of Home Economics, States Relations Service, in co-operation with the Dairy Division, has made the following studies of cheese cookery:

Either cream or Neufchâtel cheese may be combined with such foods as olives, green peppers, pimientos, pickles, different kinds of nuts, various vegetables, and nearly all fruits. In addition to the desirable blending of the flavors of cheese and the other ingredients, the combinations give spice, color, and attractiveness, increase the food value, and afford a variety of dishes easily and quickly prepared.

The following recipes illustrate a few of the many ways of serving these cheeses. Cream or Neufchâtel cheese may be used in each of the following recipes unless otherwise noted:

SALADS.

PLAIN CHEESE SALAD.

Cut the cheese into small pieces and scatter them over lettuce leaves. Serve with French or mayonnaise dressing.

CHEESE AND PIMIENTO SALAD.

Stuff canned pimientos with the cheese and cut in slices. Serve on lettuce leaves with French or mayonnaise dressing.

OLIVE AND PIMIENTO-CHEESE SALAD OR SANDWICH.

Add cream or Neufchâtel cheese, chopped olives, and pimientos in equal parts. Salt to taste and form into a roll or mold. Cut into slices and serve on lettuce leaves with French or mayonnaise dressing.

CHEESE AND LETTUCE SALAD.

3 leaves of lettuce (chopped).	$\frac{1}{2}$ teaspoon salt.
1 cheese or 4 tablespoons.	$\frac{1}{2}$ teaspoon paprika.

Mix ingredients, roll into balls, and cover with toasted bread crumbs. Serve plain or on lettuce leaves with dressing.

TOMATO AND CHEESE SALAD NO. 1.

Choose medium-sized tomatoes, peel, and slice very thick. Drain well and wipe each slice. On top of each put a thick layer of cheese, mixed with chopped green peppers. Cover all with French or mayonnaise dressing and serve on lettuce. Pimiento peppers may be used instead of or with green peppers.

TOMATO AND CHEESE SALAD NO. 2.

Stuff cold tomatoes with cream, pimiento-cream or Neufchâtel cheese. Serve on lettuce leaves with French or mayonnaise dressing.

TOMATO AND CHEESE SALAD NO. 3.

Mix with the cheese chopped pimientos, celery, and olives. Season with salt and paprika. Wash and remove centers from fresh, medium-sized tomatoes, and fill the cavity with the seasoned cream cheese. Serve on lettuce leaf with salad dressing.

BLANCHED GREEN PEPPERS AND CHEESE SALAD.

Blanch peppers, cut off large end, then remove centers and put peppers on ice. Mix with the cheese:

$\frac{1}{4}$ teaspoon salt, 1 dash paprika, 6 stuffed olives, chopped fine.

While soft, press into the hollowed peppers, chill, and cut into slices. Serve on lettuce leaves with mayonnaise, or use as a garnish.

RADISH AND CHEESE SALAD.

Select medium-sized radishes, wash and scrape out the centers, adding the part removed to cream cheese to which pimientos or nuts have been added. Mix well and fill radishes with mixture and serve on lettuce leaves with dressing. This cheese combines well with almost any vegetable or fruit to make salads and sandwiches.

CHEESE AND VEGETABLE SALAD.

Slice thin some peeled tomatoes and cucumbers. Make a quantity of cheese balls, heap them on lettuce hearts in the middle of a flat dish, and put little piles of cucumbers and tomatoes alternately around them. Cover with French or mayonnaise dressing and serve.

POTATO AND CHEESE SALAD.

Salad dressing.

1 egg.

$\frac{1}{4}$ teaspoon of salt.

$\frac{1}{4}$ cup of vinegar.

$\frac{1}{4}$ cup of water.

Mustard or curry powder.

1 cheese or 4 tablespoons.

Diced potatoes.

Add to well-beaten egg the other ingredients and cook over water until thick, then add the cheese and stir until melted and smooth. Pour over the potatoes, which have been cubed or diced, and mix well. Chopped celery, sweet peppers, or celery seed change the taste and give variety.

CHEESE AND CELERY SALAD.

1 stalk celery.

2 cheeses or $\frac{3}{4}$ cup.

1 teaspoon of salt.

2 tablespoons of ground pecan nuts.

$\frac{1}{4}$ tablespoon of paprika.

2 tablespoons of finely cut celery tops and lettuce leaves.

Separate the celery, clean thoroughly, and place on ice until crisp. Mash cheese until soft, and add salt, paprika, and ground nut meats. Dry the celery, fill the hollow part with the cheese mixture, and roll in finely chopped parsley or celery tops. Cut into 2-inch pieces and serve on crisp lettuce leaves with French dressing.

PRUNE AND CHEESE SALAD.

Cream the cheese with mayonnaise and to each half cup of the mixture add one-quarter cup of English walnut meats, broken. Roll into tiny balls and place inside seeded prunes which have been cooked for 10 minutes in lemon juice and water. Serve on lettuce leaves with mayonnaise.

PINEAPPLE AND CHEESE SALAD.

Place slices of pineapple on lettuce leaves, cover with slices or pieces of cheese, and serve with mayonnaise dressing.

PEACH AND CHEESE SALAD.

Peel large peaches and cut into halves; remove stones and put on ice; place on lettuce and add a spoonful of mayonnaise. In center of each place a ball of cheese.

ASTORIA SALAD.

4 large figs.	8 large dates.
1 teaspoon lemon juice.	$\frac{1}{2}$ cup almonds.
1 cup of cheese, creamed.	

Add the lemon juice to the cheese, salt to taste, and beat thoroughly. Remove stones from dates. Add figs and almonds, chopping all together and beating to a smooth paste. Add cheese mixture and mix well together, form into molds or balls, and serve on lettuce leaves with salad dressing mixed with an equal quantity of whipped cream. Maraschino cherries may be used instead of figs.

HONOLULU SALAD.

Put a slice of raw or canned pineapple on a nest of lettuce leaves. Mix one-half cup of cheese with a pimiento pepper; add a dash of salt and cayenne or tabasco. Form into balls and place one in the center of each slice of pineapple. Serve with mayonnaise dressing.

CHEESE SALAD AND PRESERVES.

Place pieces of the cheese on lettuce leaves and cover with French or mayonnaise dressing. Serve with currants or other fruits, preserved in honey or sugar.

NUT AND CHEESE SALAD.

Cover whole blanched almonds with cheese and form in egg shapes. Roll in finely ground almonds. Pile in nests of lettuce leaves. Serve with mayonnaise dressing. Peanuts and many other nuts may be used equally satisfactorily.

PEAR AND CHEESE SALAD NO. 1.

Mix chopped pecans with the cheese, form into balls, roll them in finely chopped nuts, and place in cavities of California white pears. Serve on lettuce leaves with mayonnaise.

PEAR AND CHEESE SALAD NO. 2.

Wash ripe pears and cut in two (crosswise). Scoop out the center from one half and fill the pear cup thus made with the cheese, to which chopped nuts, salt, and paprika have been added. Cover with the other half, chill, and serve with mayonnaise.

CHEESE AND FRUITS.

CHEESE AND CHERRIES.

Select large whole cherries; wash, drain, and stone. Fill the centers with cheese and serve on lettuce leaves with mayonnaise. The cheese may be prepared with nut meats or pimientos before filling the cherries.

CHEESE AND DATES.

Select large, firm dates; wash, drain, and stone. Stuff with cream cheese seasoned with salt and paprika. Chill and serve on a nest of lettuce leaves with mayonnaise or special cheese dressing.

CHEESE SURPRISE.

Select tart apples of uniform size; core, pare, and steam in a sirup of 1 cup of sugar to 2 cups of boiling water until soft. When cool place on the ice to chill thoroughly. Season cream cheese with salt and paprika and mix together until soft. Cover the apples with the cheese mixture. Chill again before serving. Serve on lettuce.

CHEESE AND APPLES.

Mix with one cheese 12 dates (seeded and chopped) and 1 tablespoon of chopped pecan nuts. Wash and core good eating apples and fill the centers with the cheese mixture. Chill and serve on crisp lettuce leaves with French or mayonnaise dressing.

FROZEN CHEESE WITH FIGS.

Mash two cheeses and beat them with half a cup of stiffly beaten cream until smooth; flavor, and sweeten to taste. Put into covered pail or mold and bury in ice and salt for 4 hours. Slice in pieces 2 inches thick and cut round with biscuit cutter. In the side of each piece put a preserved fig or some other fruit.

TOMATO RABBIT.

2 tablespoons of butter. $\frac{1}{2}$ cup of milk.
2 tablespoons of flour. $\frac{1}{2}$ teaspoon of soda.
 $\frac{1}{4}$ cup of stewed and drained tomatoes.
5 cheeses, or $1\frac{1}{2}$ cups.

Cook the butter and flour together, add milk, and as soon as the mixture thickens add tomatoes and soda. Then add cheese and seasoning. Serve on toast, whole wheat, or Graham bread.

BAKED CHEESE AND TOMATO.

Select good whole tomatoes, remove part of contents, stuff with cheese, and bake. Green peppers may be used in the same way. Serve hot.

CHEESE SANDWICHES.

CUBAN SANDWICH.

Between two slices of bread place lettuce with a little salad dressing or salt on it, then a slice of cheese, and finally thin slices of dill pickles or a little chopped pickle.

TOASTED CHEESE SANDWICHES.

Plain bread and butter sandwiches with fairly thick slices of cheese between are toasted, and on picnics or at chafing-dish suppers are often browned in a pan in which bacon has been fried.

CHEESE AND JELLY SANDWICH.

Spread slices of bread with a layer of cream cheese, then a layer of jelly. Place another layer of bread on top to form a sandwich, then toast.

CHEESE-DATE-NUT SANDWICH.

Season cream cheese with chopped dates and nuts and serve as sandwich filling for graham crackers.

CHEESE FOR SANDWICHES.

Add salt, a few drops of vinegar, paprika, and a speck of mustard to one cream or Neufchâtel cheese. Mix thoroughly and spread between thin slices of bread. Anchovy essence may be added to the mixture if desired.

CHEESE PASTE FOR SANDWICHES.

$\frac{1}{2}$ cup of tomato ketchup.	1 teaspoon onion juice.
2 tablespoons chopped pecans.	1 teaspoon of salt.
2 cheeses or $\frac{3}{4}$ cup.	$\frac{1}{4}$ teaspoon paprika.

Cream the cheese and mix with the other ingredients. Spread between thinly cut slices of bread. This will make sufficient paste for about 24 ordinary sandwiches.

CHEESE AND JAM SANDWICHES.

Brown bread.	Cheese with jam, marmalade, or pre-
Cheese.	served ginger.

Slice bread thin and spread with layer of jam or marmalade; strawberry and peach flavors give best results. Spread a layer of cheese over jam and cover with another slice of bread. Press and serve.

CHEESE AND VEGETABLES.

CHEESE AND POTATO PUFFS.

1 cheese or 4 tablespoons.	$\frac{1}{2}$ teaspoon of salt.
1 cup hot seasoned mashed potatoes.	1 dash of paprika.
1 egg.	$\frac{1}{2}$ teaspoon parsley chopped fine.

Mix cheese and potatoes, add salt, parsley, paprika, and yolk of egg well beaten. Fold in the stiffly beaten white of egg, place by spoonfuls on a greased pan, and bake until a golden brown.

CHEESE-POTATO CAKES.

Mix one cheese with $2\frac{1}{2}$ cups of cold mashed potatoes; season with salt, pepper, or a little paprika. Form into cakes and fry quickly in a little fat.

CHEESE ROLLS.

A large variety of rolls may be made by combining legumes—beans of different kinds, cowpeas, lentils, or peas—with cheese, and adding bread crumbs to make the mixture thick enough to form into a roll. Beans are usually mashed, but peas or small Lima beans may be combined whole with bread crumbs and cheese, and enough of the liquor in which the vegetables have been cooked may be added to get the right consistence. Chopped spinach, beet tops, or head lettuce may be used instead of the legumes.

CHEESE AND BEAN ROAST.

1-pound can kidney beans or equivalent of other cooked beans.	Bread crumbs.
3 cheeses or 1 cup.	Salt.

Mash the beans or put through a meat grinder. Add cheese and bread crumbs enough to make the mixture sufficiently stiff to be formed into a roll. Bake in a moderate oven, basting occasionally with fat and water. Serve with tomato sauce. This dish may be flavored with onions, chopped and cooked in butter and water.

CHEESE AND CELERY RELISH.

Cut stalks of deep-grooved celery into pieces about 2 inches long. Fill grooves with Neufchâtel, cream, or pimiento cheese and serve with bread and butter as a salad course or serve as a relish.

TOMATOES AND CHEESE.

Broil slices of tomatoes, season with salt and paprika, place on slices of bread, cover the broiled tomatoes with seasoned cheese, and place in oven until cheese is melted. Serve at once.

CHEESE AND PARSLEY BALLS.

Season the cheese and mold into balls, chill, and roll in finely chopped parsley. Serve as garnish or on lettuce leaves with French or mayonnaise dressing.

CHEESE AND CEREALS.

Cheese may be combined with many breakfast foods. It can be melted with the "ready-to-serve" breakfast foods or simply served with them, and it may be cooked with the home-cooked kinds. This is a very rational dish as regards the proportion of nutrients and may be served as the principal item of a breakfast menu, thereby eliminating the meat. It may be served without milk and sugar.

OATMEAL WITH CHEESE.

2 cups of oatmeal.	1 tablespoon of butter.
1 cup of cheese.	1 level teaspoon of salt.

Cook the oatmeal as usual. Shortly before serving stir in the butter and add the cheese. Stir until cheese is melted and blended with oatmeal. The cheese flavor may be increased or decreased by the quantity added. Wheat breakfast foods (parched or unparched), corn meal, and hominy may be prepared in the same way.

CHEESE WITH MUSH.

Cheese may be added to corn-meal mush or to mush made from any of the corn or wheat preparations now on the market. The addition of cheese is particularly desirable when the mush is to be fried. Simply put the cheese in with the meal and cook until well blended. It fries much more satisfactorily and has a rich, desirable flavor.

BAKED CHEESE AND RICE.

1 cup of rice.	3 cheeses or 1 cup milk as needed.
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Cook the rice in salted water, and put into a buttered baking dish alternate layers of rice and cheese. Pour over them milk enough to come halfway to the top, cover with bread crumbs, and brown in the oven.

CHEESE AND EGGS.

DEVILED EGGS WITH CHEESE.

Deviled eggs are very much improved by the use of cream or Neufchâtel cheese mixed with the egg yolk. The cheese prevents the crumbling of the yolk, as is usually the case with deviled eggs. Beat the eggs slightly, mix them with the other ingredients, and cook over a very slow fire, stirring constantly so as to melt the cheese by the time the eggs are cooked.

BAKED EGGS WITH CHEESE.

- | | |
|--|---------------------------------|
| 4 eggs. | $\frac{1}{4}$ teaspoon of salt. |
| 2 or 3 cheeses or from $\frac{3}{4}$ to 1 cup. | Few grains cayenne pepper. |
| 1 cup of fine, soft, stale bread crumbs. | |

Break the eggs into a buttered baking dish or into ramekins, and cook in a hot oven until they begin to turn white around the edges. Cover the mixture with crumbs, cheese, and seasoning. Brown in a very hot oven so that the cheese is brown without the eggs being cooked too much. White sauce may be put over eggs before the cheese mixture is added.

CREAMED CHEESE AND EGGS.

- | | |
|---------------------------------|--|
| 3 hard-boiled eggs. | Speck of cayenne. |
| 1 tablespoon of flour. | 4 slices of toast. |
| 1 cup of milk. | 2 or 3 cheeses or from $\frac{3}{4}$ to 1 cup. |
| $\frac{1}{2}$ teaspoon of salt. | |

Make a thin white sauce with the flour, milk, and seasoning. Add the cheese and stir until melted. Chop the whites of the eggs and add them to the sauce. Pour over the toast, then cut the yolks in small pieces and sprinkle over the whole.

CHEESE OMELET.

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| 2 eggs. | $\frac{1}{2}$ tablespoon of butter. |
| 2 teaspoons of milk. | $\frac{1}{4}$ teaspoon salt. |
| 1 cheese or 4 tablespoons. | Dash of pepper. |

Cream the cheese until soft, add milk, then the well-beaten yolks of the eggs, and then the stiffly beaten whites. Place a little butter in an iron skillet and when hot pour in the omelet. Cook until brown, then place under flame in an oven until slightly dried out on top, turn, and serve on hot platter. Season with salt, pepper, and butter.

SCRAMBLED EGGS WITH CHEESE.

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| 3 eggs. | $\frac{1}{2}$ teaspoon of salt. |
| 3 cheeses, or 1 cup. | Pinch of nutmeg if desired. |
| 1 tablespoon of chopped parsley. | |

CHEESE SOUFFLÉ.

- | | |
|---------------------------------|----------------------------------|
| 3 eggs. | 5 tablespoons of honey. |
| $\frac{1}{4}$ teaspoon of salt. | $\frac{1}{4}$ cup of sour cream. |
| 1 cheese, or 4 tablespoons. | |

Beat cream and cheese until smooth. Add honey so that it is well blended, add yolks, then beaten whites. Fill pastry cases and bake 25 minutes. They will puff over the cases. If preferred, they may be baked in custard cups instead of cases. Serve with cheese sauce made by heating thick cream and cheese, blending with spoon and beater.

MISCELLANEOUS CHEESE DISHES.

Cream or Neufchâtel cheese may be used in preparing many dishes which may take the place of or supplement meat dishes, as well as in the recipes given below. It is not recommended to use them instead of American Cheddar or other cheese, but to show the many ways of using them satisfactorily. Since these cheeses are not ripened, they have a mild-cheese flavor in contrast to the strong-flavored cheese. The Cheddar cheese is often cheaper, has a more pronounced flavor, and when obtainable should be used in the regular way.

When these cheeses are made in the home, and are therefore not so expensive, or when a mild-cheese flavor is desired, or when the other cheeses are not easily obtainable, they will be found very acceptable in preparing many dishes, a number of which are given below. The nutritive value of the menu and the number of palatable dishes which may be served will be greatly increased by their use.

In many recipes calling for cheese the omission of butter and the substitution of a smaller quantity of skim milk or water for whole milk is very desirable and more wholesome because of the high fat and water content of the cheese.

PIMIENTO AND CHEESE ROAST.

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| 2 cups of Lima beans, cooked. | Bread crumbs. |
| 2 canned pimientos, chopped. | Salt and pepper. |
| 2 cheese or $\frac{3}{4}$ cup. | |

Put the cheese, beans, and peppers through a meat grinder. Mix well and add bread crumbs until stiff enough to form into a roll. Brown in oven, basting occasionally with fat and water.

FRIED BREAD WITH CHEESE.

Cut stale bread into thin pieces and put two pieces together with cheese between them. Dip in a mixture of egg and milk and fry in butter or other fat.

CHEESE SAUCE.

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| 1 cup of milk. | From 1 to 3 cheeses or from 4 table- |
| 2 tablespoons of flour. | spoons to 1 cup. |
| | Salt and pepper. |

Thicken the milk with flour and add cheese just before serving, stirring until melted.

This sauce may be used in preparing creamed eggs, to pour over toast, with macaroni, rice, Welsh rabbit, or for baking with crackers soaked in milk.

CHEESE AND MACARONI.

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| 1 cup of macaroni broken into small pieces. | 1 teaspoon of onion juice. |
| 1 tablespoon of chopped green peppers. | 1 teaspoon of chopped parsley. |
| 1 tablespoon of butter. | 3 cheeses or 1 cup. |
| | Salt and pepper. |

Cook the macaroni in boiling water until tender; rinse in cold water, and cook parsley, onion, and green peppers in a little water with butter. Mix all ingredients together with the cheese and bake in a moderate oven about 15 minutes.

PLAIN CHEESE AND MACARONI.

Cook macaroni until done, drain water off, add salt and pepper and cheese, stirring until cheese is melted. Serve at once.

CHEESE, RICE, AND TOMATO.

1 cup of cooked rice.	$\frac{1}{2}$ of medium-sized green pepper.
1 teaspoon of salt.	$\frac{1}{4}$ of medium-sized onion.
1 cheese or 4 tablespoons.	3 medium-sized tomatoes.

Cook tomatoes, onion, and green pepper 20 minutes. Add cooked rice and seasoning, then the cheese. When melted, pour over heated crackers or toast.

SAVORY CHEESE.

3 slices of bacon.	1 tablespoon of milk.
1 cheese or 4 tablespoons.	$\frac{1}{4}$ teaspoon of salt.
$\frac{1}{2}$ teaspoon onion juice.	Dash of paprika.

Crisp the bacon and break it into small pieces. Mix cheese seasoning and milk with bacon. Heat thoroughly and serve on toast or crackers.

CHEESE FONDUE.

1 cheese.	3 teaspoons of milk.
$\frac{1}{4}$ cup of fine bread crumbs.	$\frac{1}{4}$ cup of hot water.
$\frac{1}{4}$ teaspoon of salt.	2 eggs.

Cream the cheese and add salt, hot water, bread crumbs, and milk, then the well-beaten yolks of the eggs. The well-beaten whites are then gently added. Pour the fondue into a greased baking dish and place in a pan surrounded by hot water. Cook in a slow oven about 30 minutes or until firm. Test in center with knife.

BERMUDA RELISH.

Arrange slices of Bermuda onion on toast with salt, pepper, and a drop of tabasco sauce on each; then add a thin layer of cream cheese. Bake long enough to melt the cheese.

CHEESE TOAST.

1 cheese, or 4 tablespoons.	$\frac{1}{8}$ teaspoon paprika.
$\frac{1}{2}$ teaspoon of salt.	

Slice bread thin and cut into round pieces with biscuit cutter. Cream the cheese, add salt and paprika, spread evenly on bread, and brown in oven.

CHEESE CRUSTS.

Cut some stale bread in slices 2 inches thick. Trim crusts and spread with one tablespoon of cheese. Season with salt and paprika. Lay in baking pan and brown in oven.

CHEESE BALLS, FRIED.

$\frac{1}{2}$ cup of dry brown or victory bread crumbs.	$\frac{1}{4}$ teaspoon of salt.
1 cup of cheese.	$\frac{1}{4}$ teaspoon of mustard.
1 egg.	A few grains of cayenne pepper.

Mix ingredients, shape in small balls, and fry in deep fat.

FROZEN CHEESE.

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|------------------------------------|-------------------------------|
| 4 cheeses, or $1\frac{1}{2}$ cups. | 2 eggs. |
| 1 quart of milk. | $1\frac{1}{2}$ cups of sugar. |
| 1 pint of cream. | |

Beat the cream and cheese together until smooth. To the well-beaten yolks of the eggs add the sugar and vanilla to taste, and the milk. Strain and freeze. When partly frozen add the well-beaten whites of the eggs.

CHEESE RELISH.

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| 1 cheese, or 4 tablespoons. | 1 tablespoon of butter. |
| 2 tablespoons of Roquefort cheese. | 2 green peppers. |
| $\frac{1}{2}$ stalk celery. | $\frac{1}{2}$ tablespoon of paprika. |
| 1 large Bermuda onion. | |

Rub the cheese and butter to a smooth paste, then add the paprika and the onion, celery, and pepper, chopped fine. Chill and serve with hot toasted cracker.

CHEESE DRESSING.

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| 1 cheese, or 4 tablespoons. | $\frac{1}{2}$ teaspoon mustard. |
| 1 egg. | $\frac{1}{2}$ teaspoon salt. |
| $\frac{1}{4}$ cup cold water. | 1 teaspoon sugar. |
| 1 tablespoon vinegar. | |

Beat the egg until light, add salt, sugar, and mustard, then water and vinegar, and cook over boiling water until thick. Then add cheese and beat until light and smooth. Serve when cold. A variety of salads may be served with this dressing. Chopped hard-boiled eggs, shredded pepper, and chopped olives, mixed and served on lettuce leaves with this dressing, make an excellent salad.

Whole tomatoes, with centers removed and the center filled with chopped cabbage, make a good salad with this dressing.

CHEESE SPOON BREAD.

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| 1 egg. | $\frac{1}{2}$ cup of corn meal (white). |
| 1 cheese, or 4 tablespoons. | $\frac{1}{2}$ teaspoon of baking powder. |
| 1 cup of milk. | $\frac{1}{2}$ teaspoon of salt. |

Heat milk, salt, and corn meal in double boiler for 5 minutes. Add cheese, and when melted and cool stir in the baking powder, then add the beaten egg. Bake in greased muffin rings or bread pan about 20 minutes.

CRACKERS AND CHEESE.

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| 1 cheese, or 4 tablespoons. | 2 tablespoons of milk. |
| 1 egg. | $\frac{1}{2}$ teaspoon of salt. |
| 3 drops of onion juice. | |

Soften the cheese, add milk, seasoning, and the yolk beaten until lemon colored, and lastly fold in the stiffly beaten white of the egg. Place spoonful on toast or crackers, heat thoroughly, and serve.

GINGERBREAD.

Make a gingerbread, reducing the quantity of sugar. When cold cut in two and put in a layer of the following between the two halves:

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|---|-----------------------------------|
| 2 cheeses or $\frac{3}{4}$ cup. | $\frac{1}{4}$ tablespoon of salt. |
| 2 tablespoons of chopped dates. | Rub to a paste. |
| 2 tablespoons of pecan nuts (chopped fine). | |

CHEESE FRITTERS.

- | | |
|----------------------------|--|
| 1 cheese or 4 tablespoons. | $\frac{1}{2}$ teaspoon of onion juice, if desired. |
| 1 cup of cooked rice. | $\frac{1}{4}$ teaspoon of salt. |
| $\frac{1}{4}$ cup of milk. | Dash of paprika. |
| 1 egg. | |

Mix rice, cheese, milk, paprika, salt, and onion juice. Beat the egg well and mix with the other ingredients. Drop by spoonfuls on lightly greased skillet and turn when brown. Serve plain or with jelly.

CHEESE CROQUETTES.

Prepare the same as for cheese fritters. Chill the mixture thoroughly, mold into shape, roll in fine bread crumbs, then in diluted egg (1 tablespoon of milk or water to an egg), and again in bread crumbs. Place in greased pan and brown in oven. Serve with tart jelly.





TRANSFERRING BEES TO MODERN HIVES

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THE KEEPING OF BEES in box-hives or log "gums" is unprofitable. The care that bees need in order to gather a fair crop of honey can be given only if the beekeeper is able to examine the bees and to move the combs as needed.

Probably one-third of all the bees in the United States are in hives without movable combs, and to assist the owners of such colonies to get them in proper hives this bulletin is prepared. Various methods are given, some one of which will be possible to any beekeeper, so that there is no reason for delay in making the bees productive.

Unless the bees are properly managed after transfer there is little advantage in movable-frame hives. This requires a study of beekeeping as well as promptness and care. Directions for handling bees are given in other publications of the department.

TRANSFERRING BEES TO MODERN HIVES.

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ADVANTAGES OF MOVABLE-FRAME HIVES.

HUNDREDS OF THOUSANDS of colonies of bees, representing about one-third of the bees kept in the United States, are housed in log "gums" and in box-hives and produce for their owners an insignificant amount of honey compared with what they might be made to produce if they were transferred into movable-frame hives and handled by improved methods. Following the old-fashioned method of housing bees in log "gums" and box-hives is costing many beekeepers more money than they realize. Much of the honey produced by colonies in box-hives is wasted by crude methods of securing the crop; these colonies are reduced in earning value by uncontrolled swarming, and the annual loss of bees which die in winter because of lack of protection or on account of insufficient winter stores is great. Since the care which is essential to the production of large crops of honey can be given only to those bees which are in movable-frame hives, it is to the advantage of all who have bees in box-hives and "gums" to transfer their bees to movable-frame hives, at the proper season, and make a study of the best methods of beekeeping. These hives should be carefully made. The model, at least, should be a factory-made hive, and the standard 10-frame Langstroth hive is recommended above all others. This may be purchased from any dealer in beekeepers' supplies. If all the beekeepers now using box-hives would do this, they would not only secure more profit from their bees for themselves but would add many millions of pounds to the honey supply of the country.

Transferring, as the word is used by beekeepers, means the removal of a colony of bees, either with or without its combs, from its home in a box-hive or "gum" into a modern movable-frame hive, and there is scarcely any work connected with beekeeping that is more trying than transferring by the old method of cutting the

combs from the old hive and of fitting them into the movable frames of the new hive. If the beginner can successfully transfer a colony from a box-hive in this way he has proved his ability to become a beekeeper. While shorter and easier methods have been devised and this method is not now generally used, there is probably no other operation connected with work among the bees in which there is an equal opportunity for the novice in beekeeping rapidly to obtain useful and necessary information regarding bee activities as in transferring by the old method. In this bulletin the easier methods also are explained.

Bes are wild animals, and man can handle them only in accordance with their natural activities if he wishes them to yield the best returns. The man who understands bee behavior can do almost anything with bees if he tries to make them do only the things it is their nature to do. It should be remembered that, for the man who does not intend to study his bees and give them the proper care, the modern movable-frame hive is no better than the box-hive, and that he who uses movable-frame hives must also study the best methods of modern beekeeping if he would make the business successful. To that end he needs to become familiar with the bee colony, to study the arrangement of combs and brood-nest, and to learn of the queen and her work. This old method of transferring gives an excellent opportunity to obtain first-hand information regarding these natural activities of the bees.

Beekeeping is applied bee behavior and, to a degree rarely seen in other branches of agriculture, success depends on a study of natural activities. Too many beekeepers work by rule of thumb, but the successful beekeeper is a student of bees, adapting his practice to changing seasons and knowing what to expect from his bees under a given set of conditions.

TIME FOR TRANSFERRING.

It is generally stated that the best time for transferring, especially by the old method, is during fruit-bloom, when the combs contain little honey and when the bees will gather nectar rather than rob. Another good time for transferring is immediately after the casting of a prime swarm when the number of bees in the hive is greatly reduced and when there is no danger of losing or injuring the queen, as she will have gone out with the swarm, leaving queencells in the hive. Transferring can, however, be done at any time when there is some nectar being gathered so that the bees will not be inclined to rob, although during a heavy honey-flow the combs will be heavy with honey, which makes them difficult to handle. Some method of transferring can be used successfully at any part of the active season if care is taken to see that the colony does not suffer later from lack

of stores. It is necessary to see that this colony gathers enough honey in time for winter, or that it is fed if need be.

If transferring is attempted at a time when robbers are bad, the work should be done inside a screened or bee-tight building, but the beginner should, if possible, choose a time when the bees are working freely and should work out of doors to avoid trouble from crawling bees. It is usually well to transfer the first few colonies in the late afternoon so that, if robbing does begin, it will stop with night.

METHODS OF TRANSFERRING.

Several methods of transferring are given here, and the beekeeper can choose the one which is best adapted to his plans and conditions. Plan 1 is interesting to one who wishes to study bee behavior but is not well adapted to large operations or to general use.

PLAN 1.—CUTTING THE COMBS FROM THE BOX-HIVE.

By this method the combs are cut out one by one and fitted into the frames of the new hive (see title-page). The bees may all be allowed to remain on the combs, the combs cut from the hive, the bees shaken or brushed into the new hive, and the combs fitted into the frames. It is better, however, first to drive most of the bees from the box-hive into an empty box by drumming and to shake the removed bees in front of the new hive as in hiving a swarm. The combs, thus freed from most of the bees, are then cut out and fitted into the frames. By the latter method there is less danger of killing the queen and less bother from the bees. If the old queen should be seen at any time during the process of transferring, she may be removed and a young queen of good stock introduced, as at this time the bees are so disturbed and disorganized that a new queen is usually readily accepted by the colony.

PREPARATION FOR THE WORK.

Before work is begun, the operator should obtain the tools and equipment necessary so that he may do the transferring quickly and may not be compelled to stop work to get some forgotten necessity. A basin or pail of water is necessary, as the operator should wash the tools and his hands frequently enough to keep them free from honey. The hive must, of course, be ready and each frame should have a thin strip of wood, say, one-half or three-fourths inch wide by about one-eighth inch thick and the full length of the frame, fastened with small nails to the end bars of the frame about halfway between top and bottom on one side of the frame only, so as to support the comb until it is securely fastened into the frame. Vertical strips may be used or the wooden strips may be omitted entirely and the combs may be held in place only by the strings. Wires properly bent so as to snap over top and bottom of frame may also be used or

the beekeeper may exercise his ingenuity in using the materials most easily available. There are also needed tools for opening the hive, such as saw, hammer, and cold chisel. A ball of soft wrapping twine and a heavy butcher knife should be provided as well as two clubs or sticks for drumming on the box-hive. A small box with an opening about the size of, or a little larger than, the bottom of the inverted box-hive is needed, into which to drum the bees, and a large board or a hive cover on which to cut and fit the combs must also be provided.

DRUMMING OUT THE BEES.

On a fine day when many of the bees are out gathering honey, a little smoke should be blown into the entrance of the box-hive or

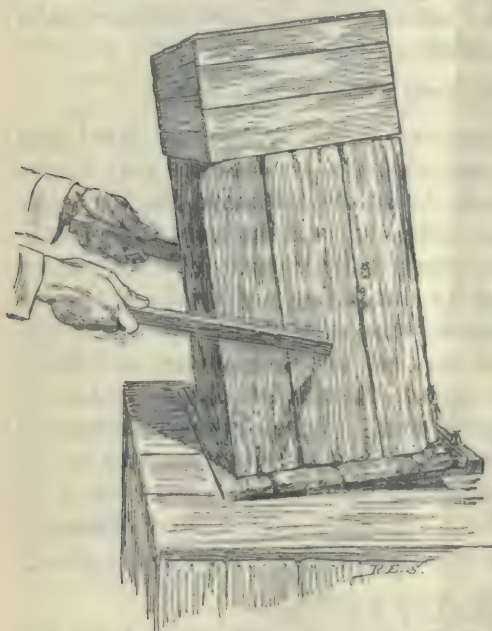


FIG. 1.—Drumming bees from an inverted box-hive.

“gum” to induce the bees to fill themselves with honey. The box-hive should now be removed to some quiet place out of the line of flight of the bees and a little distance from them. The new hive, preferably with at least one drawn comb in it, should now be placed on the old stand to receive the returning bees. A little more smoke should be blown into the entrance, the box-hive should be inverted, and the bottom removed, if there is one. The empty box is now placed over the inverted hive with the edges in contact (fig. 1) or, if the box does not fit closely, in contact at the point toward

which the combs run. A piece of burlap may be used to cover any open space between the hive and the box, but this is not necessary and is in some degree objectionable, as the operator, when burlap is wrapped around the hive, can not easily see how many bees are passing up into the box or whether the queen goes up with them. It is important that the bees should have a clear runway up the side of the box-hive between the combs and into the empty box, although the box need not fit closely at other points.

The two sticks are now used to rap on the sides of the box-hive, hard enough to jar the combs but not so hard as to loosen them. The strokes should be regular and continuous. After a few raps the bees will begin to run upward and the drumming should be continued for

perhaps 10 or 15 minutes, until three-fourths or more of the bees have entered the box on top. These bees may then be thrown in front of the new hive as in hiving a swarm. If the queen is not seen as the bees pass into the hive it will be well to drum more bees from the box-hive to avoid losing the queen while cutting out and fitting the combs. Instead of hiving the drummed-out bees immediately, the box containing them may, if desired, be set aside in the shade until the combs have been transferred into the frames and placed in the new hive.

SAVING THE COMBS.

A side of the box-hive or "gum" is now removed or split off to expose the combs, and the combs are cut out one by one and are laid aside until the brood is reached. As soon as possible a frame should be filled with comb containing brood and placed in the hive unless one has already been given. To fit comb into a frame, a large piece of comb is laid flat on the cutting board and the frame placed loosely on top. The outline of the inside of the frame is marked on the comb with the point of a knife and, after the frame is set aside, the comb is cut to fit tightly in the frame. Two or more pieces of comb containing brood may be used in one frame, but it is not wise to save small pieces of comb or drone-comb. The comb should fit in the frame snugly so that it will be held closely until fastened by the bees. After the frame is fitted around the comb as it lies on the board, both comb and board are raised to an upright position, the comb being supported on one side by the strip which has been tacked to the frame. The board is now laid aside, and the cord is fastened by giving it a wrap or two around the projecting lug of the top-bar, after which it is wrapped several times lengthwise around the frame and then three or four times around the other way, using enough cord to bind the comb securely in the frame. The cord is tied or fastened by again wrapping it tightly two or three times around the lug of the top-bar. As fast as the frames are filled they should be placed in the hive. No drone-comb should be saved, and it is usually not best to save any worker-comb unless it contains brood. At any rate, only large pieces of regular comb should be selected. Enough combs filled with honey may be saved to meet the immediate needs of the colony. Frames not filled with comb should be filled with full sheets of comb-foundation.

PREVENTING ROBBING.

After transferring is finished, all scraps of comb and wax should be placed in a closed box to be melted up later and everything should be washed clean to prevent robbing. Any good honey may be saved for home use, or it may be placed in a pan and fed back to the bees by placing it in an empty upper story over the brood-combs. When the filling of frames is completed, the "cap" or front board of the

box-hive may be so placed as to make the new hive resemble the old, as the bees may be slightly confused at first by the changed external appearance of their home.

In all this work great care should be taken that bees from other hives do not come to help themselves to honey, or robbing may be started and become serious. If robbing should begin, everything should at once be taken inside a bee-tight house and the transferring should be finished there. All work with bees should then be stopped for the day.

The bees in the new hive will immediately set to work to fasten the combs into the frames, and to cut away the strings and drag them out of the hive. After a few days the beekeeper may remove any remaining strings and may pull off the wooden strips which were tacked to the frames. If any of the combs were not evenly fastened in the frames, they may be pressed into place at this time.

PLAN 2.—DRUMMING OUT AND HIVING ON FULL SHEETS OF COMB-FOUNDATION.

This plan prevents all robbing, requires no cutting and fitting of combs dripping with honey, and all combs are built from full sheets of comb-foundation so that only straight worker combs are obtained, but occasionally the bees swarm out and abandon the new hive unless the queen is caged in the hive or is confined in it by a queen-trap at the entrance or by a queen-excluder placed between the bottom board and the hive. The success of this plan depends on getting the queen out of the old hive and into the new.

The box-hive is set a few feet to one side, and a hive with movable frames containing drawn combs or full sheets of comb-foundation is put exactly in its place so that as the field bees return they go at once into the new hive. It is well to put into the new hive a frame containing some eggs and young larvæ from which the bees may rear a queen in case the old queen has been lost: or a new queen may be given the colony if one can be obtained. The box-hive is turned upside down and three-fourths or more of the bees drummed out as in Plan 1. The box-hive containing the brood and enough bees to care for it is then placed, right side up, in a new location, preferably a few feet to the rear of the old stand and with the entrance in the opposite direction. In 21 days all the worker brood will have emerged and possibly a new queen will have been reared. These bees may be drummed out and united with their former hive-mates by allowing them to run in at the entrance. In order that there may be no fighting at this time the bees in the new hive should be well smoked, and it is well to shake the bees off from several combs from the new hive and to allow them to run in with the drummed-out bees. The old hive may now be broken up, any honey saved, and the combs melted. If nectar is not being collected, the newly established colony should be fed.

PLAN 3.—TRANSFERRING IMMEDIATELY AFTER SWARMING.

Transferring may be done immediately after a swarm issues from the box-hive. While the swarm is still in the air or clustered, the box-hive is removed to a new location a few feet from the old stand as in Plan 2. The swarm is then placed in a new hive with movable frames on the old stand and its population is further increased by the returning field bees. After 21 days the bees which have emerged from the brood in the box-hive are united with the



FIG. 2.—Construction of transfer-tube shown in figure 3.

bees in the new hive by drumming out and uniting as described in Plan 1 and the old box-hive is then broken up.

Instead of this second drive after 21 days, the box-hive may be set, three or four days after it has swarmed, with its entrance close to the new one and a bee-escape placed in the entrance of the old hive so

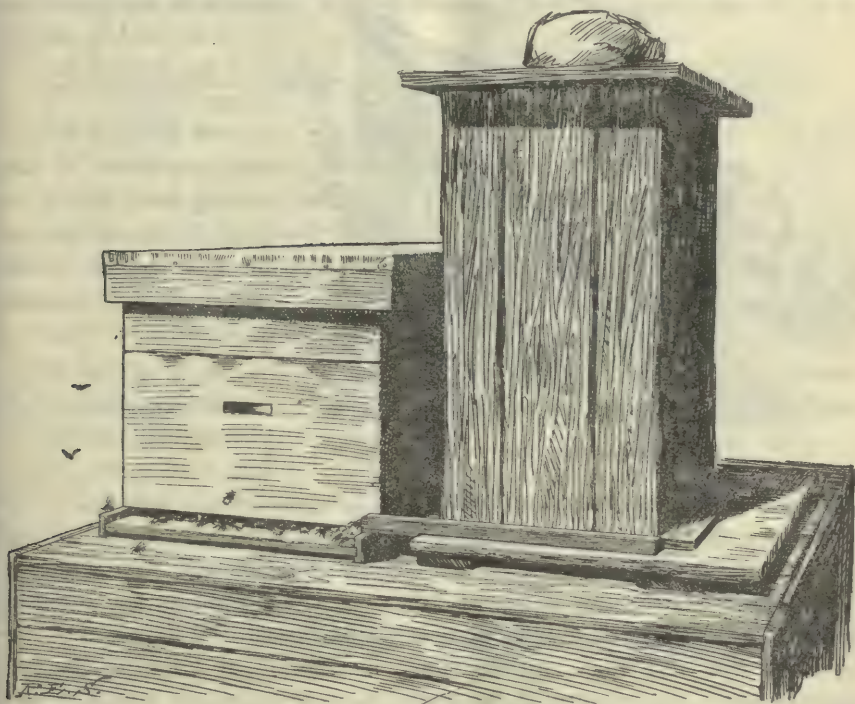


FIG. 3.—Transferring bees by means of transfer-tube.

that the young bees as they come out to fly can not return but must go into the new hive and add to its numbers.

THE USE OF A TRANSFER-TUBE.

Instead of using a bee-escape, the entrance to the box-hive may be closed by a wooden transfer-tube (fig. 2), with the opening of the tube at the entrance of the new hive (fig. 3). Nearly all the emerging

bees will enter the new hive where the queen is, instead of returning through the tube into the old hive. It would be well, as there are few bees in the box-hive, to shade it and to have in it one or more holes covered with wire cloth to avoid the possibility of the combs melting down. In 21 days the box-hive will contain only a few bees, possibly some honey and drone-brood, and it may then be broken up and the combs melted into wax.

PLAN 4.—TRANSFERRING BY PLACING A NEW HIVE OVER THE BOX-HIVE.

Another method, which is in some respects better than the one just given and which is especially useful where much transferring is to be done with a minimum of work, is to place the box-hive with its largest surface uppermost, usually on its side, with the combs on edge so that they will not break down. The bees in the box-hive should

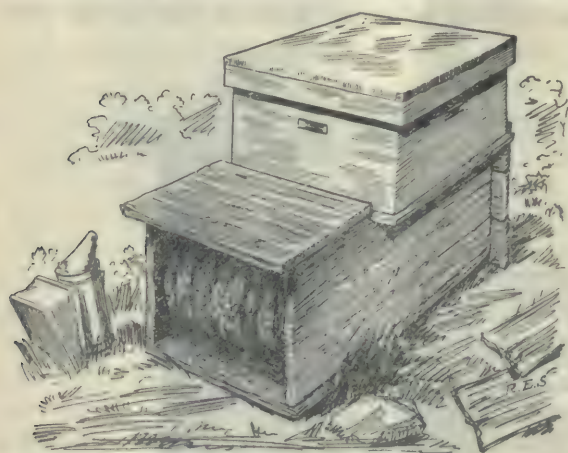


FIG. 4.—Transferring bees by setting hive on top of box.

be well smoked before the hive is turned on its side, and it should not be moved to another location. What is now the top side of the box-hive should be removed by splitting it into strips one or two inches wide, and these strips should be carefully removed so as to avoid mutilating the combs. The prepared hive containing combs or comb-foundation, at least one comb being used, if possible, is then set on the box-hive over the greatest cluster of bees, and a piece of board placed over any part of the box-hive not covered by the new hive (fig. 4). If any part of the new hive extends over the box-hive, the opening should be closed with a lath or a strip of board. What is now the front of the hive may, unless there is danger of robbing, be left entirely open, and this will cause the bees to work up into the new hive much sooner. If the bees are likely to rob, a board may be set up partly to close the front of the hive.

If the box-hive has no comb in the top (caused by having been robbed the previous season) the space should be filled with straw or shavings, the modern hive set over the part where the comb is, and a board laid over the straw. This will prevent the building of any more comb in the box-hive. If there is some honey in the top of the old hive, the bees will remove it if the cover is pried off, little

by little, several times during the season, until finally it can be removed completely, leaving both ends of the hive open. By this time the bees will have moved all the honey into the new hive, the queen will have established her brood-nest there, and the bees will have transferred themselves. If the beekeeper wishes, he may, after the queen has begun to lay eggs above, put a queen-excluder between the new hive and the old, which will prevent the queen from returning to the box-hive. This usually will not be necessary, as the bees will probably abandon the box-hive as a brood-chamber, since its combs are so much exposed. After the brood has all emerged from the combs in the box-hive the new hive may be placed on the regular bottom-board, the old hive may be broken up, and the combs may be rendered into wax. Supers should be placed on top of the new hive as needed, even while it is on the box-hive, to prevent the bees from returning to the abandoned brood-nest. This plan usually prevents swarming for the season and enables the bees to store the full crop of honey.

PLAN 5.—CATCHING THE SWARM FROM THE BOX-HIVE AUTOMATICALLY.

This method, like the preceding one, takes advantage of the fact that in many sections of the country bees in box-hives and "gums" are almost sure to swarm, and it provides an easy method of transferring for those who may not be familiar with beekeeping work and who do not care to undertake the work of transferring by the usual methods.

PREPARATION OF EQUIPMENT.

The things needed are: (1) A 10-frame hive of Langstroth size, complete with cover, bottom-board, and frames containing full sheets of comb-foundation or drawn combs. It is desirable to have at least one drawn comb in the hive if possible. In the front end of this hive body, near the lower edge, is to be bored a one-half or three-fourths inch hole so placed that a passageway, of a tube of wire cloth or of a bored-out block or of several small pieces of wood, may be placed to connect this hole with the queen-release hole in a queen-and-drone-trap. (2) A wood-wire or wood-zinc queen-excluder. (3) A queen-and-drone-trap.

The cleat is removed from the rear end of the bottom-board, leaving an opening at the rear as well as at the front of the bottom-board. On this bottom-board is placed the queen-excluder, beespace side up, and on this again is placed the prepared hive-body, after the hole has been bored in it as just described.

A queen-and-drone-trap with the queen-release slide drawn out is attached to the front of the hive and a tunnel or tube of wire cloth (fig. 5) or a bored-out block is attached, providing a continuous connection from the queen-release hole in the queen-and-drone-trap to

the hole in the hive-body, so that a queen caught in the trap can return only into the prepared hive-body and will be retained there by the queen-excluder below it.

The colony to be transferred is now set back and the prepared hive is placed so that its entrance occupies the same position as the original entrance to the box-hive. The box-hive is then placed immediately in the rear of the new hive with the entrance close to the rear opening and the space between the two hives is tightly connected so that the only entrance to the box-hive is through the queen-and-drone-trap and over the bottom-board of the prepared hive (fig. 5). All or part of this connection between the two hives may be made of wire cloth to give plenty of ventilation to the box-hive. Great care should be taken to make this connection bee-tight, and it is well to nail laths on each side of the two hives so that they can not become

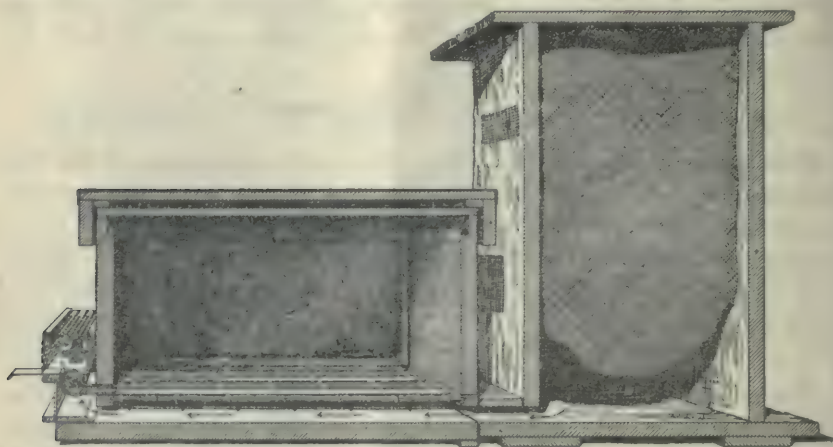


FIG. 5.—Equipment for automatic transferring at swarming time.

accidentally separated. That the hives must be tightly connected so that no queen or bee can escape through a crack and that ventilation must be given so that no bees are smothered are two important items always to be kept in mind.

TRAPPING THE SWARM.

When a swarm issues the queen is caught in the trap and can escape only through the tunnel or hole into the prepared hive and must remain there because of the queen-excluder below it. Here she will be joined by at least a part of the returning swarm, and the old box-hive or "gum" may then be removed and placed beside the new hive with the entrance at right angles to it, the rear cleat of the bottom-board being replaced at this time. All of the field bees will return to the hive through the queen-and-drone-trap as usual, and will remain with the swarm.

The box-hive, the entrance of which should now be provided with a wire-cloth cone or tube bee-escape, as in Plan 3, may now be placed with its entrance close to that of the new hive. As the bees leave the hive through the escape they will enter the new hive and be added to its force. Care should be taken to shade the box-hive and to give it sufficient ventilation, through a hole covered with wire cloth if necessary, so that the combs, deprived of most of the bees, do not melt.

In three weeks all the brood in the box-hive will have emerged, when the hive may be broken up, any honey saved, and the combs melted. The few remaining bees should be shaken from the combs in front of the new hive, any queen found being destroyed or used elsewhere, and the transfer is complete.

Instead of using the bee-escape as above, the bees may be drummed from the box-hive, or the wooden transfer-tube may be used as described in Plan 3 (figs. 2 and 3).

After the box-hive is broken up the queen-and-drone-trap and the queen-excluder may be removed from the new hive and the queen-excluder, if desired, may be placed in its usual position between the brood-chamber and the super, which should be placed on the new hive as soon as needed.

REQUEENING.

In transferring by Plan 5 or by the use of the transfer-tube (Plan 3), it would be well, if the beekeeper can do so, either to buy or to raise queens so that he may requeen at the same time the transferring is done. In that case the new queen may be placed in the prepared hive in the introducing cage and the new and old hives connected up as before described except that a bee-escape is placed in the entrance of the box-hive so that the returning bees can not enter the old hive but must remain with the queen in the new hive. The new queen will soon be released and will begin laying. In two or three weeks the box-hive may be removed and broken up. The bees may be shaken in front of the trap on the new hive in the manner previously described and the queen can then be found in front of the trap and may be killed or, if a good queen, may be caged and used in transferring another colony.

TRANSFERRING FROM HOUSES OR FROM BEE-TREES.

Transferring bees from the walls of a house or from a bee-tree may be accomplished by adapting the methods previously described to the conditions involved.

If the bee-tree is cut down, the shock of the fall may so disorganize the colony that it will offer little or no resistance, and the transferring may be done by cutting out the combs and fitting them

into the frames as described in Plan 1. The same method may be followed if the branch containing the colony is cut off and lowered to the ground.

If a colony of bees in the walls of a house is so situated that a part of the siding or roof can be removed to expose the combs, the transferring may be done as in Plan 1 or, if it is desirable not to damage the house, the bees may be trapped out by the use of a spring bee-escape. An escape can also be made of a wire-cloth cone about 8 inches long, so placed over the entrance that no bees can escape elsewhere than through the small hole in the tip of the cone. This hole should be so small that only one bee can pass at a time. Any other entrances should be securely closed or the operation will be a failure.

A queen with her escort in an introducing cage, or a frame or two of comb with some bees and containing eggs and young larvæ from which the bees can rear a queen, should be placed in the new hive into which the bees are to go after being trapped out of their original home. This new hive should be supported so that its entrance is within a few inches of the original entrance which is now closed by the bee-escape.

The same plan may be used in trapping bees out of a tree if a temporary platform can be built to support a hive near the entrance to the colony. At the end of four or five weeks there will be few or no bees left in the tree or house.

If there are still bees left in the cavity at the end of this time, the beekeeper should then load his smoker with fuel and sulphur, remove the bee-escape, and brimstone what is left of the old colony. If possible the old entrance should be somewhat enlarged to facilitate robbing, and the bees in the hive will then remove all the honey from the old nest in the tree or house, carrying it into their hive on the platform. The old entrance should be securely closed so that another swarm can not enter.

To locate the hive in a desired situation, it may be carried to some place a mile or more distant, left for perhaps a week, and then moved to the permanent stand. In this way the bees lose their memory of the old location and do not return there.

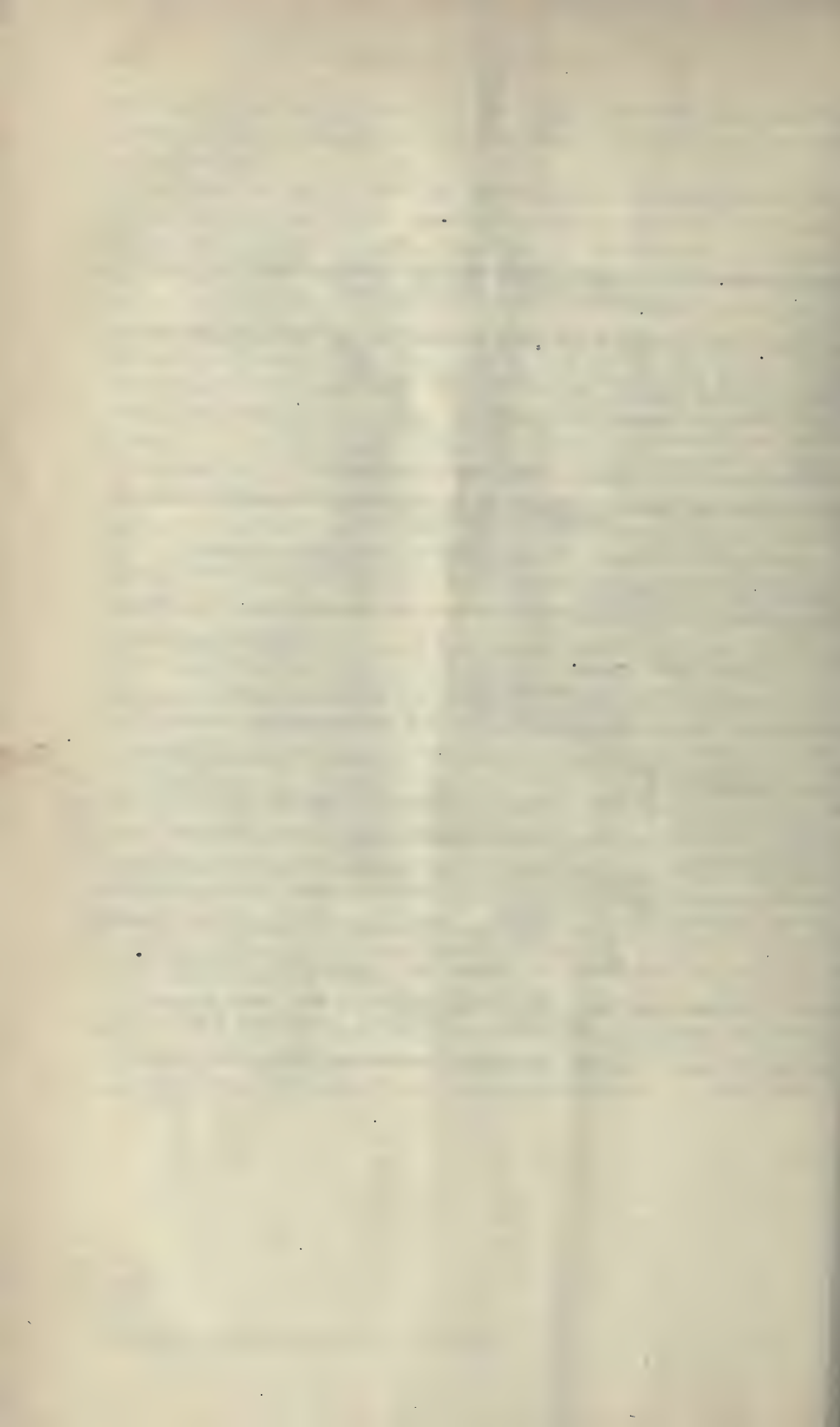
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VELVET BEANS

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FARMERS' BULLETIN 962

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry

WM. A. TAYLOR, Chief

Washington, D. C.

July, 1918

Show this bulletin to a neighbor. Additional copies may be obtained free from the Division of Publications, United States Department of Agriculture

THE VELVET BEAN is the most vigorous-growing annual legume cultivated in the United States.

With the introduction and discovery of early-maturing varieties the area planted to velvet beans in the United States increased from less than 1,000,000 acres in 1915 to more than 5,000,000 acres in 1917.

One or more varieties of velvet beans can be grown successfully in nearly all parts of the cotton belt. The Georgia and Alabama varieties constituted at least 80 per cent of the acreage in 1917.

As velvet beans are very susceptible to cool weather, they should not be planted until the soil has become warm.

This crop is especially adapted to the well-drained portions of the Atlantic and Gulf Coastal Plain areas, and it is in these sections that the greatest acreage is to be found. Velvet beans will make a fair to good growth on the heavy clay soils in the northern portion of the cotton belt provided these soils are fairly fertile.

Velvet beans are usually planted with corn. They may be planted in the same row as the corn or in separate rows. Two rows of corn to one of beans is the most popular method of planting. The yield of corn may be decreased slightly by the beans, but the value of the beans for green-manure and feeding purposes will be much greater than the loss to the corn crop.

The most important use of the velvet bean is as a grazing crop for cattle and hogs in autumn and winter.

The velvet bean is the best annual-legume crop grown in the South for soil improvement.

On account of the extensive, tangled growth of vines it is necessary to pick velvet beans by hand. From 25 to 50 cents per hundred pounds is usually paid for picking the beans.

The usual yield of velvet beans in the pods is from one-half to 1 ton per acre.

Velvet beans make an excellent feed for cattle and hogs. Feeding experiments show that 2 to 2½ pounds of velvet beans in the pod are equal to 1 pound of high-grade cottonseed meal.

VELVET BEANS.

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VELVET BEANS are one of the most important crops of recent introduction and a determining factor in developing the live-stock industry in the South. As a summer-growing annual legume which produces a large quantity of seed, and because the vines, leaves, and seed are not seriously injured by exposure in the field during winter, the crop is of great value for grazing from late fall until early spring. The beans have a feeding value

fully equal to that of wheat bran and nearly equal to that of cotton-seed meal, and so are of special importance in feeding dairy cows. Silage made by mixing the velvet bean with corn is a much better balanced ration than silage made from corn alone. For a fertilizing crop the velvet bean is of greater value than the cowpea, as it makes a much heavier growth and is less expensive.

The velvet bean first came into notice as a forage and fertilizing crop about 1890, at which time its cultivation was confined almost wholly to Florida, but with the introduction and development of earlier ripening varieties its common use has now extended northward to Virginia and Tennessee, the area covered by the crop in 1917 being estimated at more than 5,000,000 acres.

DESCRIPTION.

Velvet beans are the most vigorous-growing annual legumes cultivated in the United States, the vines often reaching a length of more than 50 feet. (Fig. 1.) The leaves are petioled and trifoliate. The membranous leaflets, which are from 3 to 10 inches long and about two-thirds as broad, are shorter than the petiole, the terminal one being rhomboid-ovate and the lateral ones obliquely so. The flowers of the different varieties, which vary in color from white to dark



FIG. 1.—A young plant of the Florida velvet bean.

purple, are 1 to 1½ inches in length and are borne in groups of one to three in long pendent racemes.

Velvet beans produce two distinct types of pods, one being covered with a dense, black, velvety pubescence, as in the Florida and Georgia varieties, while in the other type the pubescence consists mostly of short white or grayish hairs, as in the Lyon and Chinese varieties. In all kinds the pods have more or less short bristles which cause a nettleslike

irritation of the skin when handled early in the season, but most of this pubescence disappears soon after maturity, leaving the pods smooth and black. The pods of some varieties are only 2 to 3 inches in length, while those of others may reach a length of 5 to 6 inches. The seeds may be nearly spherical or a flattened oval, like the Lima bean, and they vary from nearly white to mottled brown, brown, and black. Varieties which commonly produce mottled seeds may produce occasionally an entirely white or an entirely colored seed.

Velvet beans have no deep taproots, but they produce an abundance of rather fleshy surface roots, which are often 20 to 30 feet in length and abundantly supplied with nodules varying from one-fourth to 1½ inches in diameter. The plants are rarely attacked by root-knot.

HISTORY.

While the Florida velvet bean has been grown for more than 40 years as an ornamental vine for porches and trellises, its value as a soil-improving crop or as a forage crop was not recognized until more recently. As early as 1890 this plant was used to some extent for green manure in citrus orchards in Florida. From that time until the present the acreage has increased rapidly and the crop has served to winter many cattle.

The Florida velvet bean was the only species grown for forage in the United States until about 1906, but during recent years the Department of Agriculture has introduced about 20 other species, including the Chinese, Lyon, and Yokohama varieties, which have become important in certain sections of the country.

According to present information the first early-maturing variety of velvet beans was discovered in August, 1906, on a farm operated by Mr. Clyde Chapman, at Sumner, Ga. At this time several mature plants were found in a field planted to corn and Florida velvet beans. The seed of these plants was collected and planted in corn the following year and plants were produced similar in every respect to those found the previous year. In 1908 seed of this variety was distributed to some of Mr. Chapman's neighbors, but only a small quantity of it was sent out of this immediate section prior to 1912.

An early-maturing variety which so far as known resembled in every respect the one discovered by Mr. Chapman was found in August, 1908, in a field planted to corn and Florida velvet beans on a farm operated by Mr. R. W. Miller, at Broxton, Ga. The early-maturing varieties found by Mr. Chapman and Mr. Miller are known as the "Georgia" or "Hundred-Day Speckled."

Another early-maturing velvet bean was discovered in 1911 by Mr. H. L. Blount, at Flomaton, Ala. This variety, now known as the "Alabama," was found in a field planted to corn and Florida velvet beans. It is a much more vigorous growing and later maturing variety than the Georgia, but it matures considerably earlier than the original variety.

It is very probable that early-maturing velvet beans were also found by other people and that they were present but unobserved in other fields. There seems no doubt that the Georgia, Alabama, and other early-ripening varieties are simply early-ripening kinds of the Florida velvet bean.

VARIETIES.

There are now many varieties of the velvet bean grown in the United States. These differ from each other principally in growth of vine; color of flowers; size, shape, and pubescence of the pods; size, shape, and color of the seeds; and in the length of time required to mature. While these varieties vary greatly in many ways, the common name "velvet bean" is applied to all.

THE FLORIDA VELVET BEAN.

The Florida velvet bean makes a very rank growth of vine and requires a season of eight or nine months without frost to mature. The purple flowers are borne in short clusters, and the pods, which



FIG. 2.—Mature pods of the Florida velvet bean. (Natural size.)

are 2 to 3 inches in length, are nearly straight, blunt at each end, and covered with a black velvety pubescence. (Fig. 2.) The seeds are nearly spherical, about three-eighths of an inch in diameter, and usually grayish mottled with brown. (Fig. 3.) White seeds are produced occasionally, and a white-seeded variety has been isolated, but this variety has shown no special superiority over the one with mottled seeds.

THE GEORGIA VELVET BEAN.

The Georgia velvet bean, sometimes called "Early Speckled" or "Hundred-Day Speckled," is a sport of the Florida velvet bean. (Fig. 4.) This variety makes a much less vigorous growth and yields somewhat less seed to the acre than the original Florida variety, but otherwise it is practically the same. As this plant matures in 110 to 130 days, it is adapted to all parts of the cotton belt, and it is one of the best varieties for the extreme northern portion of it.

The plants do not mature in 90 to 100 days, as the name "Ninety-Day Speckled," or "Hundred-Day Speckled," indicates. Numerous tests in many sections of the South and observations of hundreds of fields show that the average date of maturity of this variety is about 120 days. Occasional plants have been noted where the first few pods matured in 90 to 100 days, but this should not be taken as the date of maturity for the crop, as it requires several weeks longer for most of the pods to mature.

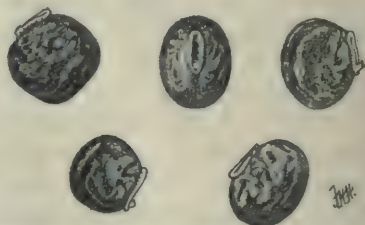


FIG. 3.—Seeds of the Florida velvet bean. (Natural size.)

THE ALABAMA VELVET BEAN.

The Alabama velvet bean is very similar to the Georgia variety except that it makes a more vigorous growth and matures about six weeks later. It is very probable that a considerable portion of the

acreage planted in 1917 with seed purchased as the Georgia or Hundred-Day Speckled was seed of this variety, as it is impossible to distinguish between the seeds of the two plants. The Alabama variety is adapted to the country south of central Georgia, central Alabama, and central Mississippi.

THE OSCEOLA VELVET BEAN.

The Osceola velvet bean is a hybrid between the Florida and the Lyon varieties developed by Mr. John Belting at the Florida Agricultural Experiment Station at Gainesville. The white or rarely purple flowers of this vigorous-growing plant are borne in rather short racemes. The pods are 4 to 5 inches in length, flat, ridged lengthwise, covered with a black velvety pubescence, and bear from four to six, usually five, seeds. (Fig. 5.) The seeds are slightly larger than those of the Lyon or Yokohama variety and usually are mottled with brown, although occasionally white seeds are produced. (Fig. 6.) The pods are nearly free from stinging hairs.

This plant matures in 150 to 160 days and is therefore earlier than the Florida and later than the Georgia and Yokohama sorts. It is adapted to the country south of a line running through the center of the States of Georgia, Alabama, and Mississippi. This midseason-maturing variety is rapidly becoming popular, owing to the fact that it yields heavily.

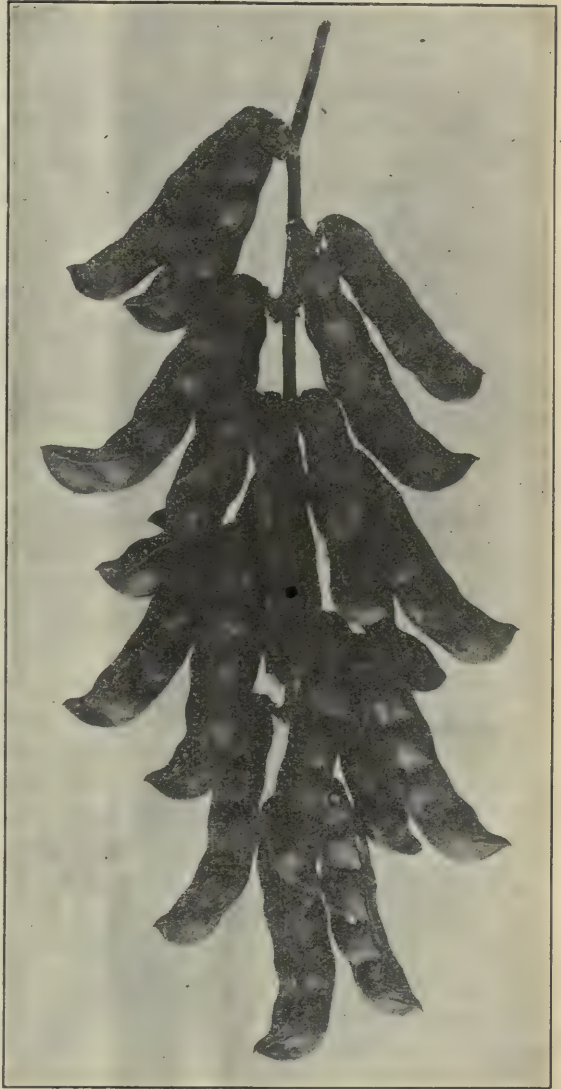


FIG. 4.—A well-developed raceme of the Georgia velvet bean.
(One-half natural size.)

THE LYON VELVET BEAN.

The Lyon velvet bean was introduced in 1907, the first specimens being obtained from Pampanga Province, Luzon, Philippine Islands. This plant makes a vigorous growth of vine and requires a long season to mature, seldom ripening more than 10 days earlier than

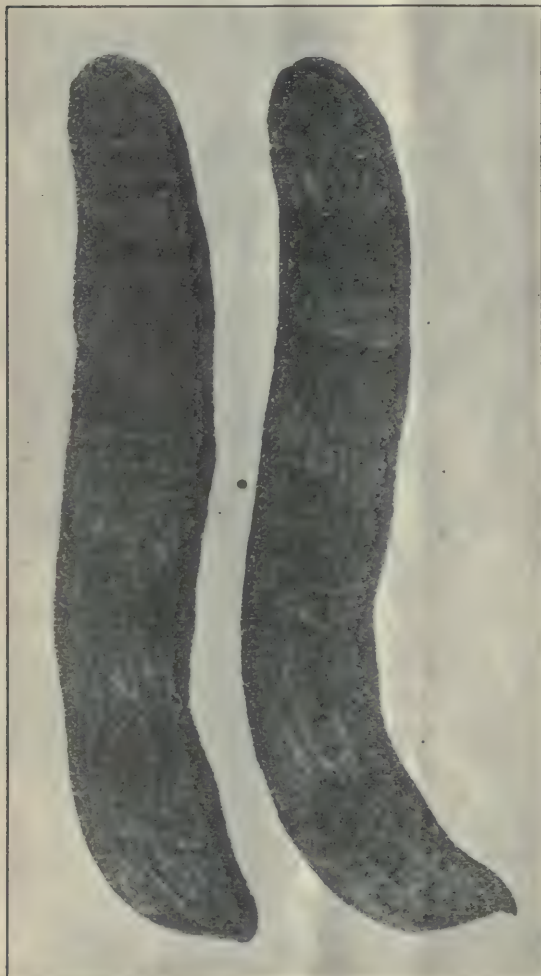


FIG. 5.—Mature pods of the Osceola velvet bean. (Natural size.)

the Florida bean. The white flowers are borne on pendent racemes which often reach a length of 2 to 3 feet. The pods are 5 to 6 inches in length, flattened, wrinkled lengthwise, and covered with a grayish pubescence, but becoming nearly smooth when mature. (Fig. 7.) They have a tendency to split open and shatter the seeds when still in the field. The ash-colored seeds are similar in size and shape to seed of the Lima bean. (Fig. 8.)

THE CHINESE VELVET BEAN.

The Chinese velvet bean was introduced from Tehwa, China, in 1909. In most respects this variety is similar to the Lyon, although the vine does not make quite as vigorous a growth and the flower clusters are much shorter. This

plant ripens about six weeks earlier than either the Lyon or the Florida variety. For this reason it will mature much farther north. It is recommended by the Louisiana Agricultural Experiment Station for planting in that State. It usually matures before frost south of central Georgia, central Alabama, and central Mississippi.

THE YOKOHAMA VELVET BEAN.

The Yokohama velvet bean was obtained from the Yokohama Nursery Co., Yokohama, Japan, in 1909. This plant produces the smallest vine growth of any of the introduced species and is not a heavy yielder. It is the earliest maturing species thus far introduced, requiring 110 to 120 days to ripen. It should ripen before frost in the Atlantic Coast States south of Washington, D. C. The purple flowers are borne on short racemes. The pods are 4 to 6 inches in length, flat, quite pointed at each end, and covered with a rather long white pubescence. (Fig. 7.) The seeds are ash colored, oblong, flattened, and about two-thirds of an inch in length. (Fig. 9.)

This species has several undesirable characters. Many of the pods form so close to the ground that they become water soaked with each heavy rain, causing many to decay; also the pods split readily and shatter the seed in hot, dry weather.

THE WHITE HAIRLESS VELVET BEAN.

One of the many hybrids produced by the Office of Forage-Crop Investigations is a cross between the Florida and the Lyon varieties. In 1914, seeds of this hybrid were sent to Mr. H. C. White, of Putney, Ga., who has cultivated the plants since that time. By careful and repeated selection several distinct forms were secured, the most promising of which has been named the "White Hairless." This vigorous-growing plant produces purple flowers and pods that are very smooth at maturity. The seeds are large and white, or occasionally mottled. This variety ripens well in central and southern Georgia.

DISTRIBUTION.

The Florida velvet bean seldom matures more than a few pods to the north of the extreme southern portions of Georgia, Alabama, and Mississippi, but with the introduction or development of early-maturing types the area to which this crop is adapted has been gradually extended northward until it now comprises nearly the entire cotton belt. (See fig. 10.) Most of the varieties, and especially the Georgia and Yokohama, will make considerable growth as far north as the Ohio River, but when the velvet bean is planted north of the southern boundary of Tennessee in the Piedmont section and north of southeastern Virginia in the Coastal Plain area it should be planted primarily as a soil-improving crop, for only in years with



FIG. 6.—Seeds of the Osceola velvet bean.
(Natural size.)

favorable growing seasons and late fall frosts will many pods mature. As the Florida variety has been grown for a long time in the southern portion of the Gulf States as a grazing and green-manure crop, it was only natural that the farmers in sections where it failed to mature fully should be the first to take advantage of newly introduced and

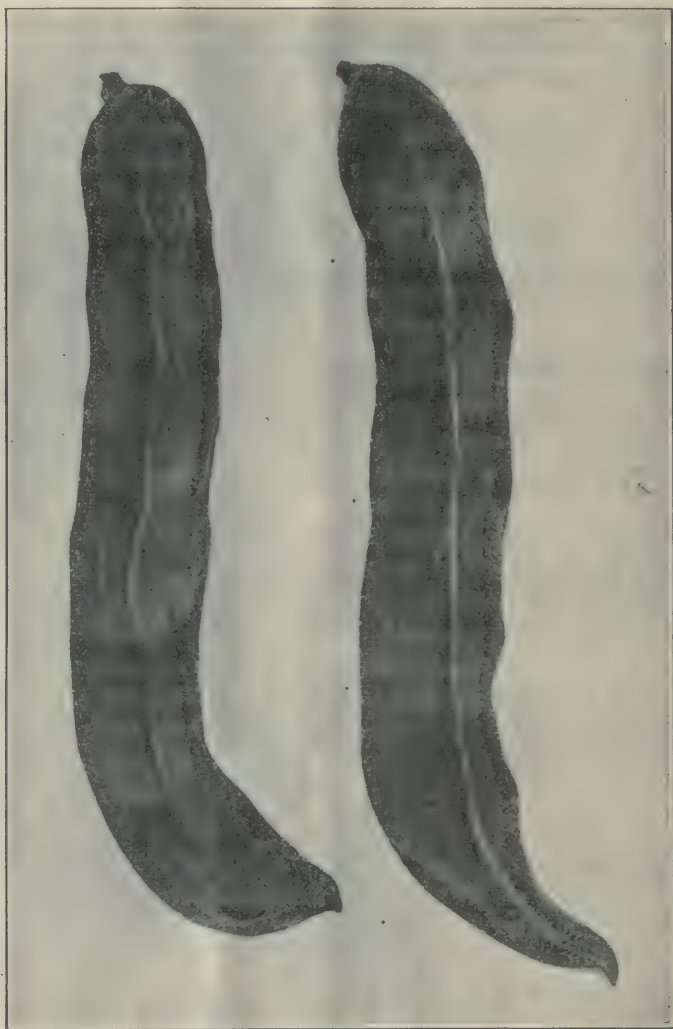


FIG. 7.—Pod of the Lyon velvet bean on the left and of the Yokohama velvet bean on the right. (Natural size.)

early-maturing varieties which promised to give better results. There are other reasons which contributed to the rapidly increased acreage of velvet beans in the Gulf States, the most important of which was the serious damage done by the cotton boll weevil in recent years, making it necessary to change the methods of farming. As corn and velvet beans are well adapted to this section, and as both can be

handled as cash crops, large acreages were planted. The drop in the price of cotton in the winter of 1914-15 also caused a much-increased acreage of velvet beans the following summer, and the favorable results obtained that year were largely responsible for the greatly increased acreage in 1916 and 1917. This plant has been grown at least experimentally in all the sections to which it is adapted, and the successful results obtained the last two years justify the increased acreage which will be planted in 1918.

The acreage of the six States leading in velvet-bean production for 1916 and 1917 is given in Table I.

TABLE I.—Areas devoted to velvet beans in six Southern States in 1916 and 1917.¹

State.	1916	1917	Increase in 1917 over that of 1916.	State.	1916	1917	Increase in 1917 over that of 1916.
	<i>Acres.</i>	<i>Acres.</i>	<i>Per cent.</i>		<i>Acres.</i>	<i>Acres.</i>	<i>Per cent.</i>
Alabama.....	1,100,000	2,334,000	112	South Carolina.....	50,000	188,000	276
Georgia.....	370,000	1,300,000	251	North Carolina.....	84,000	138,000	64
Mississippi.....	302,000	705,000	133	Total.....	2,356,000	5,165,000	
Florida.....	450,000	500,000	11	Average.....			119

¹ The figures for 1916 are compiled from those given by the Bureau of Crop Estimates and by State and district agents, and those for 1917 by the Bureau of Crop Estimates.

Previous to 1916 velvet beans were grown mainly in Florida, and the area planted in the entire South in any one year did not exceed 1,000,000 acres.

SUITABLE SOILS.

Velvet beans are especially adapted to the well-drained portions of the Atlantic and Gulf Coastal Plain areas. It is in this section that the greatest acreage is to be found. In this region the velvet bean will make a profitable growth on newly cleared land and also on soil that has been under cultivation for a long time. In many sections it is used extensively on cut-over pineland and on sandy soils as a soil-improving crop, as it has been found that it will produce more vegetable matter under such conditions than any other annual legume grown at the present time.

Velvet beans make a fair to good growth on the heavy clay soils in the northern portion of the cotton belt provided these soils are fairly fertile, but on poor, compacted soils in this area it is questionable whether they will do better than cowpeas. This crop will not succeed on cold, wet soils and should never be planted before the soil has had time to become warm.

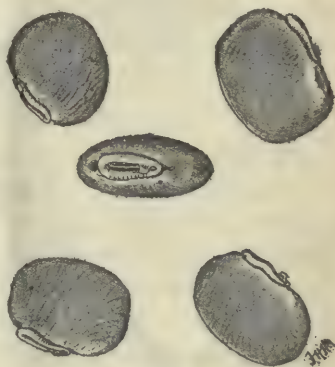


FIG. 8.—Seeds of the Lyon velvet bean.
(Natural size.)

FERTILIZERS.

Even though velvet beans make a fair growth on poor soils, it has been found profitable in some sections to make a small application of fertilizer at the time of seeding, though many farmers do not use fertilizer in planting this crop. Where it is used, the mixture and quantity are the same as are applied to corn.

Velvet beans, through the nodules on their roots, are able to secure nitrogen from the atmosphere, and most of this nitrogen is returned to the land when only the pods are picked or when the crop is pastured and the roots and uneaten portions of the plants decay; therefore, the soil on which velvet beans are grown for a few years will increase considerably in nitrogen content. Phosphorus and potassium, the other two elements which are largely used in commercial fertilizers, must be taken directly from the soil by legumes as by other crops.

Experiments conducted by the Mississippi Agricultural Experiment Station at McNeill show that the yield of the Georgia velvet bean

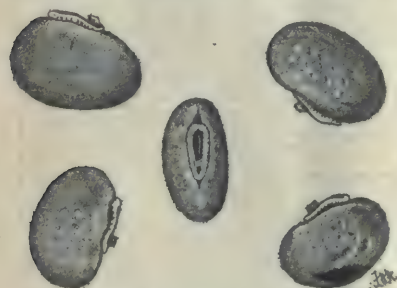


FIG. 9.—Seeds of the Yokohama velvet bean.
(Natural size.)

was increased 2.8 bushels per acre by an application of 200 pounds of cottonseed meal, while the results from applications of kainit were negative. No experiments are reported which show the direct effect of acid phosphate, but the Mississippi station recommends 100 to 200 pounds of acid phosphate per acre for velvet beans in the southern part of that State. When this crop

is to be planted on poor land it is recommended that an application of acid phosphate be made to at least a portion of the field. The results from this trial should determine the desirability of using acid phosphate in the future.

INOCULATION.

The inoculation of velvet beans has been given little consideration, as it has been assumed that the soil throughout the velvet-bean belt has become inoculated through some other agency. As a rule, no apparent lack of inoculation exists when velvet beans are planted on land for the first time, but instances have been noted where the growth of the vines has been materially increased by inoculation.

Experiments conducted by the Office of Soil-Bacteriology Investigations proved that the same strain of organism that inoculates Lima beans, cowpeas, and lespedeza, or Japan clover, also inoculates velvet beans. As lespedeza grows voluntarily over most of the South and as cowpeas have been planted widely for many years in all the velvet-bean region, it is easy to understand why the velvet bean has succeeded so well without artificial inoculation. The large acreage

planted the past three years has served also to inoculate the soil and to increase its inoculating organisms, for the seeds undoubtedly carry some inoculation, and the roots of suitable hosts serve as the best medium for rapidly increasing the inoculating bacteria in the soil. However, when velvet beans are to be planted on soil which has not in recent years grown any of the crops inoculated with this strain of the organism, it is advisable to inoculate the soil or seed.

TIME OF PLANTING.

Velvet beans will not germinate well in cold or wet soil, and the young plants are very susceptible to frost. On this account they should not be planted until all danger of frost is past and a good seed

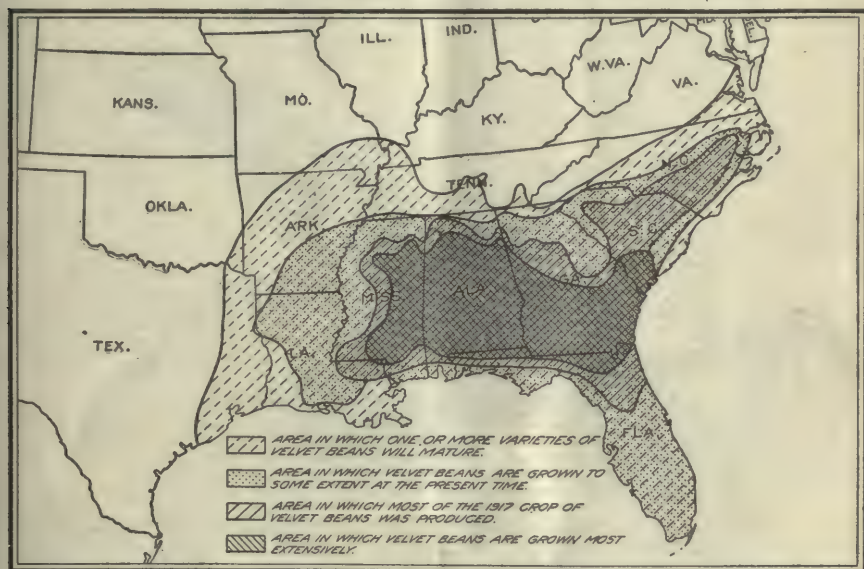


FIG. 10.—Map of the southeastern United States, showing the distribution of velvet beans.

bed can be prepared, or about cotton-planting time. However, when late-maturing varieties are used it is necessary to plant the seed as soon as the soil is in good condition, so that the plants will have as much time as possible for maturing before frost. With early-maturing varieties, such as the Georgia, the date of planting may extend over a period of six weeks or two months in the southern portion of the Gulf States, but even when early varieties are used in the northern part of the cotton belt it is necessary to plant the seed as early as possible, or at corn-planting time. In the Coastal Plain section of the Gulf States, the early planting of early-maturing varieties has been found undesirable by some farmers, as the beans mature so early that the pods of even such varieties as the Georgia will split and shatter the seed to a certain extent, and the foliage will shed before the corn is gathered and the stock are turned into the

field; so, when the crop is to be pastured, many farmers prefer to have the beans frosted before all of the pods are matured rather than to have them mature too early. As most of the beans are grown with corn and as usually it is best to plant corn early, it is better in many cases to grow varieties which can be planted at the same time as the corn and which will mature at the desired time. When this is to be done, the Alabama variety will prove more satisfactory than the Georgia in the southern portion of the cotton belt, for it not only matures five to six weeks later, but it produces a larger vine growth and yields more abundantly.

Growers of velvet beans do not agree as to the best time to plant the beans in the corn. In some sections it is the common practice to plant the corn and beans at the same time, while in other sections

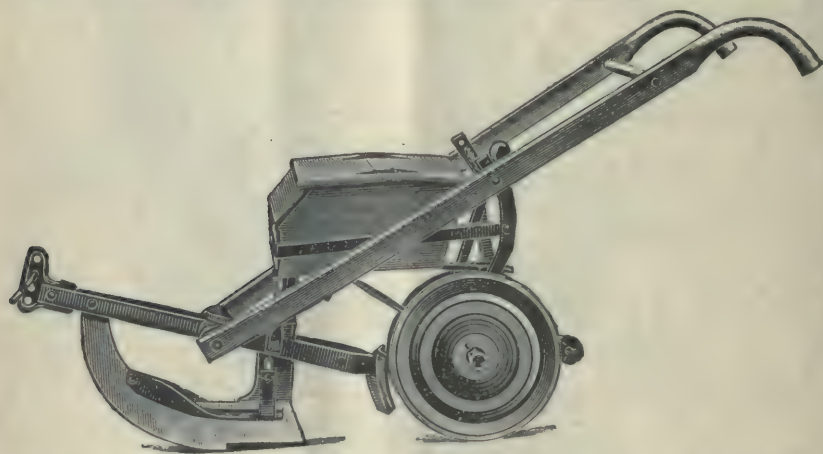


FIG. 11.—Planter used for planting both corn and velvet beans in the same row at the same operation.

the beans are planted some weeks later than the corn. The method of planting the two crops, the variety of beans used, and the labor available should determine this matter. When late-maturing varieties are to be grown, it is necessary to plant them at the same time as the corn, provided the soil is warm and the danger of frost is over; but when early-maturing varieties are used, and especially in the southern portion of the cotton belt, it is best to plant the corn some time before the beans. Where sufficient labor is available, the beans may be planted at a later date by hand in the rows of corn. On the more fertile types of soil the method of planting two rows of corn and one row of beans is used extensively, and when an early variety of velvet bean is used in this way it may be planted later with no extra expense. However, on the poorer soils, where velvet beans should be planted in every row of corn, it is a saving of labor to use a planter which will place both kinds of seeds in the same row and at the same operation. (See fig. 11.) The length of the growing

season for an average year can be approximately determined from the frost lines shown in figure 12, and this, together with the time required for the different types to mature, should give an idea as to the best time of planting.

The length of time required for the ripening of any variety varies greatly with the time of planting. Velvet beans grow well only when the weather is warm, and they make little progress when the soil and air are cold or even moderately cool. The warmer the weather when the seed is planted the more rapid will be the growth of the plants and the shorter the time required to reach maturity.

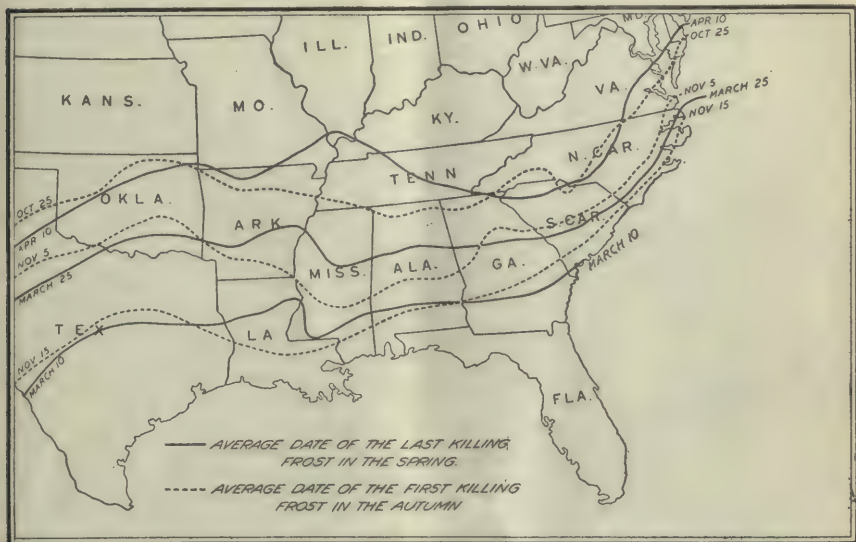


FIG. 12.—Map of the southeastern United States, showing the average dates of the last killing frost in the spring and the first killing frost in the autumn. The three sets of lines represent the approximate northern limit of the late, medium-early, and early maturing varieties of velvet beans.

METHODS OF PLANTING.

Velvet beans should be planted with some supporting crop, and corn answers this purpose very well. (Fig. 13.) In fact, at least 95 per cent of the acreage in 1917 was planted with corn. In 1913 the Florida Agricultural Experiment Station planted the Chinese beans in 4-foot rows without a supporting crop and in alternate rows with sorghum. The average yield of 3 acres planted alone was 23.2 bushels of hulled beans per acre, while the 1 acre planted in alternate rows with sorghum produced 26.9 bushels of hulled seed. In 1916 the Georgia Agricultural Experiment Station conducted similar tests and found that the yield of beans was increased when no supporting crop was used. Pearl millet, Japanese sugar cane, and other strong-growing plants are used also for this purpose, but as corn is an important crop in the area to which the velvet bean is adapted it is used generally.

It is the consensus of opinion that the yield of corn is slightly decreased by the beans, but this will depend largely upon the rate and date of planting the beans and upon the fertility of the soil. When corn is planted several weeks earlier than the beans it is not likely to be damaged, as the vines will not make sufficient growth to pull it down before the ears are nearly mature. However, when late-maturing varieties are planted on fairly fertile soil at the same time as corn, the yield of corn will undoubtedly be decreased, as some of the corn will be pulled down and will probably mold. Even though the yield is decreased the value of the beans for green manure



FIG. 13.—A field of corn and velvet beans in which the beans were planted in every row of corn.

or feeding purposes will be much greater than the loss to the corn crop. The cost of picking the corn is higher when velvet beans are planted with it than when planted alone. The increased cost is estimated by farmers who have had much experience with these crops at 5 cents per bushel. Several methods of planting corn and velvet beans are now in general use, and any one of these will give good results when carefully followed.

When the beans are planted by hand they should be dropped 18 to 24 inches apart in the row on poor soil and about twice that distance apart on fertile soil. This method should be followed when the corn is to be cut for silage or where the soil is poor and the vines will not make a vigorous growth.

The planting of corn and beans in separate rows is rapidly becoming the most popular method, and especially that of planting every third row to beans. (Fig. 14.) When this method is used, the beans may be planted at the same time as the corn or at a later date, as the cultivation of the corn will not interfere with the planting and cultivation of the beans. Even though the beans are planted at the same time as the corn, the corn will have an opportunity to make considerable growth before the bean vines are grown sufficiently to twine about the stalks. In addition to this advantage, the gathering of the corn is



FIG. 14.—Corn and velvet beans planted in separate rows. This method of planting gives the corn an opportunity to become well established before the beans have made sufficient growth to twine around the stalks.

facilitated greatly, and especially so when the Georgia and Yokohama varieties are used, as the vines do not make much growth between the two adjacent rows of corn, where the person who does the gathering may walk without difficulty. However, when the beans are planted in every row or in every other row, the vines are likely to form such a tangled mass that it will be more difficult to gather the corn.

Many farmers who feed hogs extensively plant alternate rows of peanuts and corn, with velvet beans in the corn rows. The entire crop is then pastured. On land where peanuts do well this mixture produces an abundance of feed of a well-balanced ration and will produce a better quality of pork than a feed of either peanuts or velvet beans without the corn.

RATE OF SEEDING.

The rate of seeding will vary with the purpose for which the crop is grown. When beans are planted with corn and it is desired to secure as much corn as possible, the beans should not be planted so closely as to interfere with its growth, and from 2 to 3 quarts per acre will be sufficient; while if a heavy crop of beans is wanted and the corn is not of first importance, twice as much seed should be used. These quantities are for the small-seeded sorts, like the Florida and Georgia, while for the larger seeded sorts, like the Chinese and Osceola, the quantities should be nearly doubled. When planted to make the heaviest possible quantity of vines, either for green manuring or as a smothering crop, from half a bushel to a bushel should be used.

CONTINUOUS CROPPING.

The Florida Agricultural Experiment Station has conducted an experiment to determine the effect upon the yield of velvet beans when grown on the same plat of ground continuously for a number of years. While it is stated that there was no noticeable difference in the growth of the plants from year to year between the continuously planted plat and the check, the yield of seed secured from the continuously planted plat showed a marked decrease. The results obtained are shown in Table II.

TABLE II. — *Effect of continuous planting upon the yield of velvet beans at the Florida Agricultural Experiment Station, 1907 to 1912, inclusive.*

Year.	Yield per acre of shelled beans (bushels).		Year.	Yield per acre of shelled beans (bushels).	
	Continuously planted plat.	Check plat.		Continuously planted plat.	Check plat.
1907.....	25	21	1911.....	(¹)	(¹)
1908.....	15	23	1912.....	10	20
1909.....	11	28			
1910.....	14	22	Average.....	15	23

¹ Destroyed by caterpillars.

As will be seen by Table II, the average yield for five years on the continuously planted plat was 8 bushels per acre less than that of the check plat. Experiments at Biloxi, Miss., showed similar results after three successive plantings.

It is much better to plant some nonleguminous crop after velvet beans have been planted for one or two years, and this can be done by adopting a rotation that will include the desired acreage of corn and beans. Where early-maturing varieties are planted in corn and the crop is pastured closely, the yield may not be decreased for several years, but this practice is not as desirable as rotation.

CULTIVATION.

When velvet beans are planted with corn they should receive the same cultivation as the corn until the vines are so long that they will be injured. When beans are sown in rows without a supporting crop, one or two cultivations will serve to loosen the soil, check evaporation, and prevent the growth of weeds until the plants begin to run, after which the ground will be so shaded that no further cultivation will be necessary.

USES OF VELVET BEANS.

The vigorous growth of velvet beans together with their large yield of seed, which may be gathered or allowed to remain in the field without much injury during the autumn and winter, permits this crop to be utilized in a number of different ways. As an annual green-manure crop it is unexcelled. Its value as a feed for stock is now generally recognized in the South, where large quantities are used for this purpose. The use of the beans ground in the pod has increased rapidly the past year, and velvet-bean meal is now taking the place of cottonseed meal in much of the concentrated feed offered for sale. The value of velvet beans as a winter pasture either for carrying cattle through the winter or for fattening them is now well established. With an increase of cattle it is very probable that the use of this crop for winter grazing will replace to a large extent the picking of the beans for grinding, as feeding experiments indicate that but little benefit is derived from grinding the beans for cattle. The crop is utilized also for silage, hay, and as green manure.

HAY.

Velvet beans are seldom used for hay, as the vines become so long and tangled that it is very difficult to handle them. When used for this purpose it is necessary to cut the vines before many of the pods mature, in order to save the leaves, which shatter rapidly from this time until maturity. The hay is rough and coarse at best and is not relished by horses and mules. Yields of 2 to 3 tons per acre may be obtained.

SMOTHERING CROP.

When late-maturing varieties of velvet beans are planted without a supporting crop, they produce such a dense growth of vines that weeds, persistent grasses, and in many cases tree sprouts are smothered out. The Florida Agricultural Experiment Station planted a recently plowed field of strong Bermuda grass to velvet beans in 1898. In 1899 this field was planted to cassava, during which time it remained entirely free of Bermuda grass, and again in 1900, when planted to a cultivated crop, no trace of Bermuda grass was found. When velvet beans are planted as a smothering crop on new land, they should be sown broadcast, but when on old

grassland it is best to plant them in rows, so that at least one cultivation may be given before the vines begin to run. In either case 2 to 4 pecks of seed should be used to the acre.

CORN AND VELVET-BEAN SILAGE.

Velvet beans have been employed to some extent in the making of silage, and for this purpose early-maturing varieties like the Georgia are commonly used. With such a variety most of the vine growth is wrapped about the cornstalks and little trouble is experienced in cutting the corn with corn knives and in running it through the silage cutter. Silage made from this mixture turns black after it has been in the silo for a short time, on account of the juices in the velvet-bean plants, but this apparently does not impair its keeping qualities or feeding value. Stock eat silage made from this mixture as readily as that made from corn alone. Dairymen who have used this mixture speak highly of it and now use it in preference to silage made from corn or sorghum alone.

Table III gives the analysis of a sample of corn and velvet-bean silage as compared with the average of a large number of samples of corn silage.

TABLE III.—*Analysis of corn and velvet-bean silage as compared with silage made from well-matured corn.*

Kind of silage.	Number of analyses.	Constituents (per cent).					
		Water.	Ash.	Crude protein.	Carbohydrates.		Fat.
					Crude fiber.	Nitrogen-free extract.	
Corn and velvet beans ¹	1	73.7	1.0	3.5	5.5	15.6	0.7
Corn (well-matured) ²	121	73.7	1.7	2.1	6.3	15.4	.8

¹ Analyzed by the Bureau of Chemistry, U. S. Department of Agriculture.

² Analyses compiled by Henry and Morrison.

GRAZING.

The most important use of the velvet bean is as a grazing crop for cattle and hogs in the autumn and winter. It is not grazed well by horses and mules or by any stock until after it has been well matured or frosted. As the leaves, vines, and pods decay slowly when subjected to weather conditions, velvet beans will furnish feed until early spring. It is usually better to let the crop stand until it is well matured or until it is killed by frost, as the leaves will be off the plants at that time and the corn may be gathered with less difficulty. The beans needed for seed should be gathered before stock is turned into the field. The amount of grazing which will be afforded will, of course, vary with the growth of the crop and the quantity of corn which is not gathered, but it is the custom with many

cattlemen to allow one-third to one-half acre per month for each steer or cow. The usual period for pasturing velvet beans is about three months, but this may be shortened or lengthened as deemed advisable. When the acreage of beans is large and there are not sufficient cattle to stock the pasture at this rate, the grazing is often continued for four or five months, but when this is done there is necessarily some loss of feed through decay. Hogs should be permitted to follow the cattle, as they will consume practically all of the beans which have been broken from the plants and wasted by the cattle. A common practice is to allow one or two hogs in addition to the cattle for each acre of beans.

On the heavier soils of the South there is some danger of packing the land if grazing is continued in rainy weather. On this account pasturing on such soils should be done with more care than on sandy lands.

A good stand of velvet beans should produce about 200 pounds of beef and 100 pounds of pork per acre.

SOIL-IMPROVING CROP.

The velvet bean is one of our best soil-improving crops, both for soils which are naturally infertile and for those which have become somewhat exhausted by long cultivation. The ability of this plant to make a profitable growth on land so poor that most legumes will not thrive places it among the most important crops for the South. In addition to adding at a minimum cost large quantities of vegetable matter to the soil, thus making it more retentive of moisture, the nodules on the roots collect a large amount of nitrogen from the atmosphere. This nitrogen will be left in the soil when the crop is turned under and the plants decay. Even though the crop is grazed, the nitrogen and humus content of the soil will be gradually increased, as much of the nitrogen in the portions of the plants consumed by the stock will be voided.

In many sections velvet beans have proved to be the most profitable crop to plant for one or two years on newly cleared land. In addition to producing sufficient grazing or feed during this time to more than pay the cost of planting and harvesting, the fertility of the land will be so improved that other crops may be grown more successfully. The yield of seed from such ground is usually heavier than from fields which have been long in cultivation.

Many experiments have been conducted to determine the value of velvet beans as a soil-improving crop, but the Florida variety only has been used in these experiments. It is probable that better results were obtained with this species than would have been obtained with the early-maturing varieties, which do not make such a vigorous growth.

It was found at the Alabama, Louisiana, and Florida agricultural experiment stations that the green weight of the vines in an acre of velvet beans was 19,049, 22,919, and 21,132 pounds, respectively. Assuming that the weighings were made as soon as the plants were cut and the moisture content was 82 per cent, these plats produced, respectively, 3,427, 4,125, and 3,804 pounds of dry matter per acre. Moisture-free velvet-bean hay contains approximately 17.6 per cent of crude protein, and on this basis the plat harvested in Alabama contained 96.4 pounds of nitrogen; the Louisiana plat, 116.1 pounds; and the Florida plat, 107 pounds, thus giving an average of 106.5 pounds of nitrogen in the vines for an acre of Florida velvet beans. At the present price of nitrogen in the form of nitrate of soda, the value of the nitrogen alone in an acre of velvet beans yielding at this rate would be \$35.

The effect of velvet beans upon the growth of cotton.—In 1898 the Alabama Agricultural Experiment Station planted velvet beans and cotton on poor soil at Auburn. One plat of the velvet beans was cut for hay, yielding 8,240 pounds per acre, while the vines on the other plat were plowed under. In 1899 fertilizer was applied at the rate of 240 pounds of acid phosphate and 40 pounds of muriate of potash per acre, and cotton was planted in 3½-foot drills on April 21. Table IV shows the results obtained.

TABLE IV.—*Effect of a crop of velvet beans on the subsequent yield of seed cotton at the Alabama Agricultural Experiment Station in 1899.*

Crop and treatment in previous year.	Crop in in 1899.	Yield per acre (pounds).	
		Seed cotton.	Increase due to vel- vet beans.
Cotton.....	Cotton....	918	.....
Velvet beans (cut for hay).....	do.....	1,126	208
Velvet beans (vines plowed under).....	do.....	1,578	560

It will be seen from Table IV that the effect of the velvet beans upon the yield of seed cotton was very marked, and especially so where the entire crop was turned under.

At the Arkansas Agricultural Experiment Station in 1899 an experiment was conducted to determine the comparative value of cowpeas, soy beans, and velvet beans as a fertilizer for cotton. In this experiment the vines of all three plants were plowed under in November and the land bedded and planted to cotton in May. The following yields of seed cotton per acre were obtained:

	Pounds.
Cotton after cowpeas.....	1, 335
Cotton after soy beans.....	1, 488
Cotton after velvet beans.....	1, 550

The results of this experiment show that the value of velvet beans as a green-manure crop is superior to that of cowpeas and soy beans and that the velvet-bean plat produced 215 pounds of seed cotton per acre more than the cowpea plat and 62 pounds per acre more than the soy-bean plat.

The effect of velvet beans upon the yield of corn.—An experiment was conducted by the Alabama Agricultural Experiment Station which shows clearly the beneficial effect of velvet beans upon the growth of corn. In 1900, velvet beans were planted on three plats after oat harvest, and on September 10 one of the plats was cut for hay, yielding 3,632 pounds per acre. The following spring the three velvet-bean plats and a plat which had been in corn the previous year were plowed and planted to corn. Acid phosphate was applied at the rate of 100 pounds per acre to all plats except the one on which the velvet-bean vines had been plowed under. The results obtained are given in Table V.

TABLE V.—*Effect of a crop of velvet beans on the subsequent yield of corn at the Alabama Agricultural Experiment Station in 1901.*

Crop and treatment in previous year.	Crop in 1901.	Acid phosphate applied.	Yield per acre (bushels).	
			Corn.	Increase due to velvet beans.
		Pounds.		
Corn.....	Corn.....	100	13.5	.....
Velvet beans (stubble plowed under).....	do.....	100	17.9	4.4
Velvet beans (vines plowed under).....	do.....	100	25.9	12.4
Do.....	do.....	.....	21.5	8.0

It will be noted that the plowing under of a velvet-bean crop which had been planted after oat harvest practically doubled the yield of corn the following year. This is an important item, as it does not require the loss of the use of the land for an entire season and the beans may be grown at a minimum cost, since the seeding is inexpensive and disking is sufficient for planting on light soil.

An experiment to determine the effect of peanuts, soy beans, and velvet beans on the yield of corn was conducted by the North Carolina Agricultural Experiment Station at the Tarboro test farm in 1901. All plats received an application of fertilizer at the rate of 131.2 pounds of acid phosphate and 32.6 pounds of kainit per acre. The results obtained are shown in Table VI.

This experiment, as well as the one conducted by the Alabama Agricultural Experiment Station, shows that velvet beans are a most important fertilizing crop for corn.

TABLE VI.—*Effect of a crop of peanuts, soy beans, and velvet beans on the subsequent yield of corn at the Tarboro test farm of the North Carolina Agricultural Experiment Station in 1901.*

Crop and treatment in previous year.	Crop in 1901.	Yield per acre (bushels).	
		Corn.	Increase due to legumes.
Cotton.....	Corn.....	20.7	.....
Peanuts (harvested).....	do.....	21.8	1.1
Soy beans (vines plowed under).....	do.....	24.4	3.7
Velvet beans (vines plowed under).....	do.....	36.5	15.8

The effect of velvet beans upon the yield of oats.—An experiment was performed at the Alabama Agricultural Experiment Station to determine the effect of cowpeas, velvet beans, German millet, and crab-grass on the yield of oats. In May, 1897, two plats were planted with cowpeas, two with velvet beans, and one with German millet, while crab-grass and poverty weed were permitted to grow on a sixth plat. All plats were fertilized at the rate of 264 pounds of acid phosphate and 66 pounds of muriate of potash per acre. The German-millet plat and one plat each of velvet beans and cowpeas were cut for hay. All plats were plowed in September and seeded to oats on October 25, fertilizer being applied to the oats at the rate of 220 pounds of acid phosphate and 44 pounds of muriate of potash per acre. Table VII shows the results obtained.

TABLE VII.—*Effect of different crops, including velvet beans, upon the subsequent yield of oats at the Alabama Agricultural Experiment Station in 1898.*

Crop in 1897.	Yield per acre.		Crop in 1898.	Yield.		Increase over crab-grass plat.
	Grain.	Hay.		Grain.	Straw.	
	<i>Bushels.</i> (1)	<i>Pounds.</i> (1)		<i>Bushels.</i>	<i>Pounds.</i>	<i>Bushels.</i>
Crab-grass.....	.....	.....	Oats.....	7.1	231	.....
German millet.....	.....	994	do.....	9.7	361	2.6
Cowpeas.....	11	.....	do.....	28.8	1,463	21.7
Do.....	.....	2,420	do.....	34.4	2,013	27.3
Velvet beans.....	.....	3,872	do.....	38.7	1,672	31.6
Do.....	(1)	(1)	do.....	28.6	1,206	21.5

¹ Plowed under.

It will be noted that the velvet-bean plat from which a crop of hay was removed yielded 10 bushels per acre more than the plat on which the velvet-bean vines were plowed under. These results are directly in contrast to those obtained at the same station with corn on plats treated in the same manner. However, in the experiment with corn the velvet-bean crop was not turned under until the following spring, when the vines either had dried up or had partly decayed. The turning under of a large quantity of green matter usually has a detrimental effect on the yield of the succeeding crop, provided this crop is planted soon after the green-manure crop is

turned under. It is stated that the velvet-bean vines were not properly buried and the seed bed for the oats was not as compact on this plat as it was on the plat where only the velvet-bean stubble was plowed under. This would give the velvet-bean stubble plat considerable advantage in a dry winter like that of 1897-98.

An experiment to determine the effect of plowing under a crop of velvet beans, beggarweeds, cowpeas, and soy beans upon the yield of oats is reported in Bulletin No. 66 of the Arkansas Agricultural Experiment Station. The ground on which this experiment was conducted had been previously in orchard-grass sod. The yield of oats per acre following velvet beans was 53 bushels, as compared with 51 bushels after cowpeas, 49 bushels after beggarweeds, and 48 bushels after soy beans. The check plat, which had been planted to oats the previous year, yielded 36 bushels per acre.

*The effect of velvet beans upon the growth of sugar cane.*¹—Adjacent plats on a field of the Scudday plantation of the Leon Godchaux Co., which had been in cane in 1914 and 1915, were planted to velvet beans and corn and peas in 1916. That fall the velvet beans and peas were disked under and the field planted to Ribbon sugar cane. Fertilizer was applied at the rate of 500 pounds of tankage, containing $8\frac{1}{2}$ per cent ammonia and 20 per cent phosphoric acid, on that portion of the field which had been in corn and peas. In 1917 the cane on the velvet-bean plat stooped more and produced thicker and taller stems than that on the other portion of the field, yielding 24 tons per acre, containing 3,324 pounds of sugar, as compared to a yield of 12.7 tons of cane, containing 2,004 pounds of sugar, on the corn and pea land.

Residual effect from velvet beans.—The Alabama Agricultural Experiment Station has conducted several experiments which show the residual effect of turning under both velvet-bean stubble and vines.

In 1898 a plat of velvet beans and a plat of cotton were planted, fertilizer being used at the rate of 240 pounds of acid phosphate and 40 pounds of muriate of potash per acre. Cotton was planted on these plats in 1899 and corn in 1900. The results are shown in Table VIII.

TABLE VIII.—*Residual effect of a crop of velvet beans upon the yield per acre of succeeding crops of cotton and corn at the Alabama Agricultural Experiment Station in 1899 and 1900.*

Crop in 1898.	Crop in 1899.	Yield of seed cotton.	Crop in 1900.	Yield.
		Pounds.		Bushels.
Cotton.....	Cotton....	918	Corn.....	18.0
Velvet beans (vines plowed under).....	do.....	1,578	do.....	25.5

¹ This experiment was carried out under the supervision of Mr. S. F. Morse, formerly an employee of the United States Department of Agriculture.

In another experiment, sorghum was planted in 1899 on plats which had been in sorghum, cowpeas, and velvet beans in 1898. In 1900 these plats were planted to corn and fertilized at the rate of 240 pounds of acid phosphate and 32 pounds of muriate of potash per acre. The results obtained on these plats for the three years are given in Table IX.

TABLE IX.—*Residual effect of cowpeas and velvet beans on the subsequent yield per acre of sorghum hay and corn at the Alabama Agricultural Experiment Station in 1899 and 1900.*

Crop in 1898.	Crop in 1899.	Yield.	Increase due to legumes.	Crop in 1900.	Yield.	Increase due to legumes.
		<i>Tons.</i>	<i>Tons.</i>		<i>Bushels.</i>	<i>Bushels.</i>
Sorghum (cut for hay).....	Sorghum.....	3.65	.....	Corn.....	24.1	.....
Cowpeas (cut for hay).....	do.....	5.66	2.01	do.....	25.7	1.6
Velvet beans (cut for hay).....	do.....	5.80	2.15	do.....	23.9	(Decrease.)
Cowpeas (seed picked, vines plowed under).....	do.....	5.72	2.07	do.....	27.7	3.6
Velvet beans (vines plowed under).....	do.....	6.76	3.11	do.....	26.8	2.7

It will be seen from Table IX that the increase from the velvet-bean stubble and vines was very marked upon the yield of sorghum, but that their effect upon the yield of corn the second year was very slight; in fact, on the velvet-bean stubble plat the yield of corn was a little less than on the check plat.

In 1898 on reddish loam soil cowpeas, velvet beans, and cotton were planted on adjacent plats which had been fertilized alike with acid phosphate and kainit. The cowpeas and velvet beans were planted thickly in drills and the vines were turned under in March, 1899. Cotton was planted on these plats in 1899, sorghum in 1900, red oats in November, 1900, and sorghum again in July, 1901. A nitrogenous fertilizer was used on the oats, but only acid phosphate and kainit on the other crops. The results obtained with these crops are shown in Table X.

TABLE X.—*Residual effect of cowpeas and velvet beans on the subsequent yield per acre of cotton, sorghum hay, and oats at the Alabama Agricultural Experiment Station in 1899, 1900, and 1901.*

Crop in 1898.	Crop in 1899.	Yield of cotton.	Crop in 1900.	Yield of sorghum.	Crop in 1901.	Yield.	
						Oats.	Sorghum.
		<i>Pounds.</i>		<i>Tons.</i>		<i>Bushels.</i>	<i>Tons.</i>
Cotton.....	Cotton.....	837	Sorghum..	5.1	Oats and sorghum..	23.3	1.0
Cowpeas.....	do.....	1,533	do.....	8.1	do.....	26.5	1.5
Velvet beans.....	do.....	1,373	do.....	8.2	do.....	37.2	1.6

The results obtained at the Alabama Agricultural Experiment Station show that there is a residual effect for at least two years after a crop of velvet beans has been turned under, and the data in Tables IX and X indicate that the residual effect after the first year is about the same as that obtained from cowpeas.

HARVESTING.

On account of the extensive tangled growth of the vines of velvet beans it is necessary to pick the pods by hand. The cost of picking varies in different sections. Where labor is plentiful an average price of 25 cents per 100 pounds is paid, but in sections where there was a shortage of labor in the fall of 1917 it was necessary to pay as high as 50 cents per 100 pounds in order to obtain pickers.

The price paid for picking also varies with the variety grown, the large-podded, large-seeded sorts being picked much faster because they produce larger and heavier bunches than types like the Georgia. Many laborers prefer to pick the large sorts, as the Chinese and Osceola, in preference to the Georgia and Florida, even when 10 to 15 cents less per 100 pounds is paid. For the average laborer, 500 to 700 pounds of beans in the pod constitute a day's picking. Very seldom is the entire crop gathered, for pickers are often careless and at best miss many pods. On this account stock should be turned into the field after the pickers have finished, in order to consume the vines and the beans not gathered.

Velvet beans should not be gathered until the pods are thoroughly ripe and dry. When immature pods or pods which are damp are picked they will heat and mold when stored in bulk unless thoroughly stirred at frequent intervals. Many mills will not purchase beans that are not dry, and those which do buy them pay much less than they would give for beans in good condition.

Many factors, including the fertility of the soil, cultivation, and weather conditions, influence the yield of seed. It is estimated that the average yield of the total acreage planted in corn in 1917 was about 1,000 pounds of beans in the pod per acre. On fairly fertile soil the early-maturing varieties should produce 1,500 pounds per acre and the late-maturing varieties 2,000 pounds, while 1½ tons per acre is not an unusual yield. The Mississippi Agricultural Experiment Station obtained 4,400 pounds per acre at McNeill, and still heavier yields have been obtained from small areas which have been given special care.

One ton of pods will produce 20 to 22 bushels of shelled beans, the quantity depending on the variety and the amount of moisture in the pods. With varieties like the Georgia and Florida, 90 to 95 pounds of pods will usually thrash out a bushel (60 pounds) of shelled beans, while larger and coarser podded sorts, like the Chinese and Yokohama, require approximately 100 pounds of pods to produce a bushel of shelled beans.

THRASHING.

When velvet beans are to be fed to cattle or ground into meal it is not necessary to hull them; in fact, it is preferable to feed both hulls and beans to cattle, as the hulls have considerable feeding value.

For this reason the quantity of beans thrashed is ordinarily limited to those which are to be used or sold for seeding purposes. The beans may be thrashed with a flail or with one of the several thrashing machines now offered for sale. Regardless of the method of thrashing, only well-matured and thoroughly dried pods can be thrashed without difficulty. If only a few are to be hulled they may be sunned a few hours, put in an ordinary corn sack, and beaten out with a club. When larger quantities are to be thrashed it is better to use one of the machines designed for the purpose. A small machine run by hand which has sufficient capacity to enable a man and a boy to thrash 10 to 15 bushels per day can be purchased for about \$25. This machine has been used by gearing it to an automobile, and in that way about 50 bushels were thrashed in a day. A larger machine that requires a 2 to 4 horsepower engine and which will thrash 10 to 15 bushels per hour can be purchased for about \$75. Larger machines equipped with cylinders and screens to pick peanuts or shell corn may be successfully used for thrashing velvet beans by making a few changes. Such machines, requiring an 8 to 12 horsepower engine to operate them, will thrash 60 to 70 bushels an hour.

In some sections farmers have bought machines cooperatively or individuals have purchased machines and do community thrashing. Some of the grinding plants also have purchased thrashers and thrash for the public on a cash or toll basis. The price charged for thrashing varies from 15 to 30 cents per bushel of hulled beans.

When the beans are to be sold for seed or for grinding they should be thrashed whenever possible before being placed on the market. When sold in the pod they require so much storage room that the mills are able to care for only a small part of the crop, and of course they deduct the cost of storage and thrashing from the price paid the grower. When thrashed before selling, the pods can be kept for home use, and they have a feeding value equal to or better than that of cottonseed hulls. In the spring of 1917 the price of the thrashed pods was about \$15 per ton, or nearly as much as was paid for the unthrashed beans and hulls as gathered from the field.

GRINDING.

Velvet-bean meal is rapidly becoming a standard feed for live stock, and especially as the concentrated part of the many mixed feeds offered for sale on the market. In the manufacture of this meal the hard beans and tough pods are ground or, rather, crushed together by machinery especially designed for handling such material. No standard of fineness for grinding meal has been established, but up to a very recent period most of it was ground so as to pass through sieves having meshes one-fifth to five-eighths of an

inch in size. The trade is now demanding a finer ground meal, and many mills are grinding it as fine as corn meal. This meal is preferred for the manufacture of mixed feeds. It is questionable whether it is necessary to grind the beans and pods when they are to be fed to cattle at home, as practically equal feeding results will be obtained from the use of the unground pods. At most, cracking the beans is all that is required, as they absorb water very quickly when the seed coat is broken. It is impossible to grind velvet beans finely unless they are well matured and thoroughly dry. On this account some mills kiln-dry all beans before grinding. This adds considerably to the cost of manufacture, but it is necessary early in the season in order to prevent the meal from spoiling.

Velvet beans may be ground alone or with other feeds, but when ground alone the meal should be fed in combination with other feeds. A common mixture is to grind velvet beans and corn in the shuck together. In accordance with the use to be made of the feed, velvet-bean meal is used in varying proportions in the manufacture of mixed feed. In horse feeds it seldom forms more than 25 per cent of the entire mixture, while in mixed feeds for dairy cows it may run as high as 70 per cent. A popular mixed feed for dairy purposes is composed of 15 per cent cottonseed meal, 45 per cent corn-and-cob meal, and 40 per cent velvet-bean meal, while a popular horse feed contains in addition to the velvet-bean meal, corn, oats, and ground hay or straw.

In a few sections the entire cornstalks and velvet-bean vines and pods are ground together. It is doubtful whether this procedure is an economical one, because of the low feeding value of the cornstalks. It would be much better to harvest the beans alone or to pasture the entire crop. When the cost of harvesting and grinding are taken into consideration, it is quite evident that the most practical way to utilize this crop is by grazing. The cost of harvesting, hauling to the mill, and the toll for grinding is \$9 to \$10 per ton. These figures may appear rather high, but when the price of picking is figured at 40 cents per hundred pounds and the grinding at \$2 to \$4 per ton, it will be seen that the picking and grinding alone of a yield of 1,500 pounds would be \$8.25. When the expense of hauling to and from the machine is considered, the total cost of grinding the beans is increased considerably. The price charged for grinding beans on a cash basis varies from \$2 to \$4 per ton, with an average of \$3. When the grinding is done on a toll basis, one-eighth is the usual quantity charged.

Velvet-bean meal is sold for about \$15 per ton more than the cost of the unground beans. In the manufacture of this meal there is a loss of 10 to 20 per cent in the weight of the beans from the time of purchase until they are sacked and ready for the market. The loss

is mostly in the drying kilns. The moisture lost in drying will vary considerably, depending on the condition of the beans when dried and the season. A loss of 15 per cent is not uncommon when the beans are dried early in the fall, but later in the season the loss is much less. This loss in weight, together with the expense of drying, grinding, and sacking, makes the meal cost \$10 to \$12 per ton more than was paid for the beans in the pod.

FEED.

No other crop so high in feeding value can be produced as cheaply or in such quantity on the soils of the South as the velvet bean. In addition to the high feeding value and the low cost of production, this crop, unlike other legumes, may be permitted to remain in the field until late winter without serious injury, as the pods decay very slowly when subjected to weather conditions; in fact, the pods and beans are eaten more readily by live stock after they have softened.

Velvet beans may be pastured with cattle and hogs or the pods may be picked and fed to live stock either whole or after being ground. It is not necessary to grind the pods for home consumption, as practically as good results will be obtained from feeding them whole; but if the pods have been permitted to become dry it is better, although not absolutely necessary, to soak them before feeding. Feeders who have used velvet-bean meal and ground beans¹ find that a larger quantity is needed to secure the same results. It requires about 2½ pounds of velvet-bean meal or 1½ pounds of ground beans to equal in feeding value 1 pound of high-grade cottonseed meal.

As velvet beans are very high in digestible protein, great care should be exercised in feeding them to live stock, especially at first. After the stock become accustomed to the beans they should be kept in the field for only a short period each day until the crop is somewhat reduced, as excessive consumption is a waste of concentrated feed. In addition to wasting concentrated feed, overfeeding sometimes has a laxative effect similar to that caused by feeding too much cottonseed meal. For these reasons and because better gains will be obtained, this crop should be fed in combination with other feeds. This is accomplished when cattle and hogs are pastured on corn and velvet beans, as some corn will be overlooked in picking and the stover contains a relatively high proportion of carbohydrates.

COMPOSITION.

Velvet beans contain high percentages of protein and carbohydrates, thus making them a source of these valuable constituents

¹ Much confusion has been caused by the use of the term "velvet-bean meal" in referring to the products of grinding. In this bulletin "velvet-bean meal" is used to designate the product of grinding the pods and beans together, and when the beans are ground alone they are referred to as "ground beans."

needed for growing stock and milk production. Table XI shows the relative composition of the different varieties of velvet beans and of velvet-bean meal as compared with other feeds.

TABLE XI.—*Composition of different varieties of velvet beans and of velvet-bean meal as compared with other feeds.*

Portion analyzed.	Number of analyses.	Constituents, moisture-free basis (per cent).				
		Ash.	Crude protein.	Carbohydrates.		Fat.
				Fiber.	Nitrogen-free extract.	
Florida velvet bean: ¹						
Shelled beans.....		3.2	27.7	6.8	55.9	6.4
Pods.....		6.0	5.9	31.7	55.6	.7
Pods and beans (meal).....		3.8	20.1	14.9	56.6	4.6
Chinese velvet bean: ¹						
Shelled beans.....		3.4	27.7	6.4	57.8	4.7
Pods.....		5.0	5.5	28.1	60.5	.9
Pods and beans (meal).....		4.5	21.0	15.6	56.3	2.6
Kind of feed:						
Velvet-bean meal ²	5	4.5	20.3	16.5	54.5	4.4
Cottonseed meal (choice) ³	2,556	6.7	47.7	8.8	27.0	9.8
Corn meal or chop ³	5,335	1.5	10.5	2.6	81.1	4.3
Wheat bran ³	7,742	7.0	17.8	10.7	59.6	4.9
Rice polish ³	1,013	5.3	13.2	2.1	69.2	10.1
Velvet-bean hulls ²	3	6.0	5.7	30.0	57.0	1.1
Cottonseed hulls ²	66	2.9	5.1	48.5	41.3	2.1

¹ Analyses made by the Bureau of Chemistry, U. S. Department of Agriculture.

² Analyses compiled by the Office of Forage-Crop Investigations.

³ Analyses taken from Henry and Morrison's "Feeds and Feeding," sixteenth edition.

FEEDING EXPERIMENTS.

Comparatively few experiments have been conducted to determine the value of velvet beans as a feed, but sufficient work has been done to show that live stock will make excellent gains when velvet beans are fed in combination with other feeds. Most of these experiments have been made to determine the relative value of velvet beans as compared with cottonseed meal when fed to steers and milch cows. Hogs relish the shelled beans but will not eat the hulls unless they are finely ground.

Feed for steers.—At the Florida Agricultural Experiment Station velvet beans in the pod were fed in comparison with other feeds to 16 head of steers, averaging approximately 700 pounds, for a period of 84 days. These steers were divided into four lots as nearly equal in weight and quality as possible. Lot 1 received an average daily ration per 1,000 pounds of live weight of 10½ pounds of corn, 3¼ pounds of cottonseed meal, and 13½ pounds of crab-grass hay; lot 2, 6 pounds of corn, 5 pounds of cottonseed meal, 20 pounds of sorghum silage, and 14 pounds of cottonseed hulls; lot 3, 8 pounds of corn, 10 pounds of cottonseed hulls, and 12 pounds of velvet beans in the pods; lot 4, 6½ pounds of cottonseed meal and 25 pounds of cottonseed hulls. The steers which were fed corn, cottonseed hulls, and

velvet beans in the pod made an average daily gain of 2.92 pounds per head at a cost of \$7.55 per hundred pounds, while the lot fed corn, cottonseed meal, and crab-grass hay made an average daily gain of 2.58 pounds at a cost of \$9.07 per hundred pounds. In computing the cost of gain, the crab-grass hay, velvet beans, and sorghum silage were valued at \$4, \$6, and \$3 per ton, respectively, which was about the actual cost of production. The corn, cottonseed meal, and cottonseed hulls were valued at \$1.58, \$1.50, and 73 cents per hundred pounds, respectively, the market prices at the time the experiment was conducted. The results obtained in this experiment are given in detail in Table XII.

TABLE XII.—*Results obtained by feeding velvet beans in the pod in comparison with other feeds at the Florida Agricultural Experiment Station.*

Lot.	Ration fed.	Number of steers.	Duration of test.	Average weight (pounds).			Cost per 100 pounds of gain.
				At beginning.	At end.	Daily gain.	
No. 1.	Corn, cottonseed meal, and hay.....	4	Days. 84	730	947	2.58	\$9.07
No. 2.	Corn, cottonseed meal and hulls, and silage.....	4	84	723	946	2.68	10.65
No. 3.	Corn, cottonseed hulls, and velvet beans.....	4	84	705	950	2.92	7.55
No. 4.	Cottonseed meal and hulls.....	4	84	717	873	1.85	12.00

At the Alabama Agricultural Experiment Station a test was conducted to determine the relative feeding value of velvet beans in the pods and of cottonseed meal as a concentrate part of a ration for fattening steers. In this experiment 40 steers, averaging 584 pounds, were divided into two lots and fed over a period of 97 days. The ration fed to lot 1 consisted of cottonseed meal and corn silage, while lot 2 received velvet beans in the pods and corn silage. The feed given to each lot was increased or decreased from time to time, the amount varying with the quantity the steers would consume in a few hours after feeding. The cottonseed meal given daily to each steer in lot 1 was gradually increased from 2.76 pounds during the first 28 days to 6.46 pounds for the last 13 days of the experiment. The quantity of corn silage given to each steer in this lot was gradually increased from 35.4 pounds to 43.03 pounds per day. The velvet beans given daily to each steer in lot 2 were increased gradually from 5.7 pounds during the first 28 days of the experiment to 12 pounds for the last 13 days. As the steers consumed more velvet beans they ate less silage. For the first 28 days of the test each steer received an average of 31.07 pounds of silage per day, while during the last 13 days of the experiment each received an average of only 25.6 pounds. The steers which were fed cottonseed meal and corn silage made an average daily gain of 1.6 pounds at a cost of \$10.62

per hundred pounds, while those fed velvet beans and corn silage made an average daily gain of 1.5 pounds at a cost of \$9.65 per hundred pounds. In computing the cost of the gain cottonseed meal was valued at \$45, velvet beans at \$20, and corn silage at \$4 per ton. The results obtained in this experiment are given in detail in Table XIII.

TABLE XIII.—*Results obtained in a feeding experiment with steers in Alabama, showing the value of velvet beans as compared with cottonseed meal.*

Lot.	Number of steers.	Duration of test.	Average weight (pounds).			Feed for 100 pounds of gain.			
			At beginning.	At end.	Daily gain.	Weight (pounds).			Cost.
						Cotton-seed meal.	Velvet beans in the pods.	Corn silage.	
No. 1.....	20	Days. 97	589.00	746.25	1.6	258.18	.....	2,408.58	\$10.62
No. 2.....	20	97	580.25	727.25	1.5	.....	635.12	1,654.75	9.65

It will be seen from Table XIII that 1 pound of cottonseed meal was equal to $2\frac{1}{2}$ pounds of velvet beans in the pods, but that the steers fed velvet beans consumed only two-thirds as much silage as those fed cottonseed meal. The gains made by the steers in each lot were satisfactory, and careful inspection of the two lots on foot and at the packing houses failed to show any appreciable difference either in the finish of the animals or in the carcasses.

Another experiment was conducted by the Alabama Agricultural Experiment Station to compare velvet beans in the pods and corn silage with cottonseed meal and corn silage. For this experiment two lots of 15 steers each were fed on these rations for a period of 119 days. The steers which were fed velvet beans with corn silage made an average daily gain of 1.6 pounds, while those fed cottonseed meal and corn silage made an average daily gain of 1.55 pounds. The results obtained showed that 2.05 pounds of velvet beans in the pods were equal to 1 pound of high-grade cottonseed meal. This experiment is described in detail in Alabama Station Bulletin 198.

Feed for dairy cows.—An experiment was conducted at the Florida Agricultural Experiment Station to show the relative value of velvet beans in the pods and of cottonseed meal when fed in combination with wheat bran and Japanese cane silage to dairy cows. For this experiment six cows were divided into two lots, due consideration being given to the lactation period of each cow. The test was divided into four periods of 16 days each, with a space of five days between the periods, so that the cows could become accustomed to the change in feed. Each cow in lot 1 received a daily ration of 10 pounds of

wheat bran, 4.25 pounds of velvet beans, and 24.5 pounds of silage, while each cow in lot 2 received 10 pounds of wheat bran, 3 pounds of cottonseed meal, and 34 pounds of silage. The feeds were reversed during the second and fourth periods.

The results obtained in this experiment show that 816 pounds of velvet beans in the pods when fed with wheat bran and Japanese cane silage produced 348.7 gallons of milk at a cost of 13.3 cents per gallon, while 576 pounds of cottonseed meal when fed with wheat bran and more silage produced 352.5 gallons of milk at a cost of 16.5 cents per gallon. On this basis velvet beans in the pod are worth \$2.37 per 100 pounds when cottonseed meal is worth \$2.40 per 100 pounds. The weights of the cows at the beginning and at the end of the test showed that there was but little to choose between the two rations so far as maintenance of animal body and the production of milk were concerned, as all cows made a slight gain in weight.

Another experiment was made at the Florida Agricultural Experiment Station to test the relative value of velvet beans in the pods and cottonseed meal when fed to dairy cows. In this experiment one lot of cows received a daily ration of 4.25 pounds of velvet beans, 10 pounds of wheat bran, and 34 pounds of sorghum silage per head, while those in another lot were each given daily $1\frac{1}{2}$ pounds of cottonseed meal, 10 pounds of wheat bran, and $24\frac{1}{2}$ pounds of sorghum silage. The results of this experiment show that 267.75 pounds of velvet beans in the pods fed with bran and silage produced 934.6 pounds of milk, while 94.5 pounds of cottonseed meal fed with bran and less silage produced 937.1 pounds of milk.

According to Prof. M. P. Jarnagin, the Georgia Agricultural Experiment Station found that 2,035 pounds of velvet-bean meal were equal to 2,000 pounds of cottonseed meal for milk production and that $5\frac{1}{2}$ pounds of velvet beans produced 1 pound of milk as against 5 pounds of cottonseed meal to produce the same quantity.

An experiment was conducted at the Alabama Agricultural Experiment Station to compare a mixture of four parts of corn meal and six parts of velvet-bean meal and corn silage with a mixture of four parts of corn meal and three parts of high-grade cottonseed meal and corn silage. During the 56 days that this experiment was conducted the four cows receiving the mixture containing velvet beans consumed 1,370.9 pounds of velvet beans, 913.9 pounds of corn, and 6,720 pounds of silage, and produced 3,252.4 pounds of milk at a cost of \$1.47 per 100 pounds; while the four cows which received the mixture containing cottonseed meal consumed 678 pounds of cottonseed meal, 894 pounds of corn, and 6,700 pounds of silage, and produced 3,418.1 pounds of milk at a cost of \$1.33 per 100 pounds. In computing the cost of the milk the cottonseed meal was valued at \$40 per ton, the

velvet beans at \$22.50 per ton, the corn at \$1.18 per bushel, and the silage at \$4 per ton.

*Feed for pigs.*¹—An experiment to compare the relative value of corn and velvet beans as feed for pigs was conducted by the Florida Agricultural Experiment Station. In this experiment 20 pigs, averaging approximately 63 pounds, were divided into five lots and given the following ration daily for a period of 30 days: Lot 1, 12 pounds of corn; lot 2, 9 pounds of corn and 3 pounds of cracked velvet beans; lot 3, 6 pounds of corn and 6 pounds of cracked velvet beans; lot 4, 6 pounds of corn and 6 pounds of cracked velvet beans plus iron sulphate; lot 5, 9 pounds of corn and 3 pounds of cracked velvet beans plus iron sulphate. The results obtained in this experiment are given in detail in Table XIV.

TABLE XIV.—*Results obtained in a feeding experiment with pigs in Florida, showing the value of cracked velvet beans as compared with corn.*

Lot.	Number of pigs.	Duration of test.	Average weight (pounds).		Average daily gain.	Feed per 100 pounds of gain. ¹		
			At be- ginning.	At end.		Weight (pounds).		Cost.
						Corn.	Cracked velvet beans.	
		<i>Days.</i>			<i>Pounds.</i>			
No. 1.....	4	30	63.1	76.8	0.46	654.5	-----	\$13.09
No. 2.....	4	30	63.3	82.1	.63	360.0	120.0	8.64
No. 3.....	4	30	63.9	80.6	.56	268.6	268.6	8.59
No. 4.....	4	30	63.6	79.3	.52	287.0	237.0	9.18
No. 5.....	4	30	62.5	78.5	.53	421.8	140.6	10.11

¹ In figuring the cost per 100 pounds of gain the corn was valued at \$2 per 100 pounds and the velvet-bean meal at \$24 per ton.

It will be seen from Table XIV that the average daily gain of the pigs was increased materially when velvet beans were added to the ration and that the average cost of the feed to make 100 pounds of gain for lots 3 and 4, where equal portions of corn and velvet beans were fed, was \$4.21 less than for lot 1, where only corn was fed.

At the Alabama Agricultural Experiment Station a lot of 5 pigs, averaging 62 pounds each, were turned into a field of corn and velvet beans after the corn had been gathered. In addition, the pigs were fed a half ration of a mixture of corn 9 parts and tankage 1 part. Another lot of 5 pigs of similar weight was fed corn meal and tankage in a dry lot. The pigs foraging the velvet beans made an average daily gain per head of 1.23 pounds for a period of 72 days, requiring 0.38 of an acre of beans and 170 pounds of concentrates for 100 pounds of gain. The pigs in the dry lot for the same period made an

¹ Recent data indicate that velvet beans may not be a safe food for brood sows. Cases of abortion as well as of malformation of new-born pigs are reported where sows have pastured freely on velvet beans. Until further information is obtained, it is inadvisable to permit brood sows to eat velvet beans except as a small proportion of the feed.

average daily gain per head of 0.84 pound and consumed 400 pounds of concentrates for 100 pounds of gain. In this experiment an acre of velvet beans grown in corn thus replaced over 600 pounds of concentrates, or, in other words, took the place of 12 bushels of corn.

In another experiment at the Alabama Agricultural Experiment Station two lots of pigs, averaging $72\frac{1}{2}$ pounds each, were fed for a period of 90 days to compare a ration of corn meal alone with one consisting of equal parts of corn meal and finely ground velvet beans. The pigs fed only corn meal made an average daily gain of 0.81 pound at a cost of \$8.64 per 100 pounds, while those fed a mixture containing velvet beans made an average daily gain of 0.64 pound at a cost of \$9.37 per 100 pounds of gain. In computing the cost of gain, the corn was valued at \$1 per bushel and the ground velvet beans at \$34 per ton. The fat of the hogs fed the mixture was slightly darker than the fat of those fed entirely on corn. The melting point of the lard from the hogs fed corn only was 1.69° C. higher than that of the lard from the hogs fed partly with velvet beans.

Another interesting experiment was conducted by the Alabama experiment station in 1914 to determine the value of velvet beans as a pasture crop for hogs. In this experiment 15 hogs were divided into three lots. Lot 1 was kept in a dry lot and fed twice daily, while lot 2 and lot 3 had the run of 1 acre each of velvet-bean pasture. The results of this experiment are given in detail in Table XV.

TABLE XV.—Feeding experiment in Alabama, covering a period of 23 days, to determine the value of velvet beans as a pasture crop for hogs.

Lot.	Number of pigs.	Ration.	Average weight (pounds).			Feed to make 100 pounds gain.	Total cost to make 100 pounds gain. ¹			
			At beginning.	At end.	Daily gain.					
No. 1.	5	Corn, 10 parts..... Dried blood, 1 part.....	Full ration.....			70	97.6	0.92	{ 316 31.6 }	\$6.59
No. 2.	5	{ Corn, 10 parts..... Dried blood, 1 part..... Velvet-bean pasture.....	{ One-half ration.....			67.2	95.8	.95	{ 150.07 15.00 .7A }	\$4.91
No. 3.	5	{ Corn, 10 parts..... Dried blood, 1 part..... Velvet-bean pasture.....	{ One-fourth ration..			67.6	89.8	.96	{ 71.03 7.10 .9A }	\$4.02

¹ The corn was valued at \$1 per bushel, the dried blood at \$60 per ton, and the velvet-bean pasture at \$2.83 per acre, the cost of producing it.

It will be seen from Table XV that the average daily gains were practically the same for the hogs in all three lots, but the cost of producing 100 pounds of pork was much less for the hogs in lot 3 than for those in the other two lots. The velvet beans had been planted with corn, but the corn was gathered before the pigs had been turned in the pasture. Because of a poor stand and early frost the velvet beans were estimated to be only 30 per cent of a total crop.

INSECTS.

The only insect which causes serious injury to the velvet bean is the larva of the velvet-bean caterpillar, which feeds on the leaves. The moth of this caterpillar does not winter in northern or central Florida, but flies northward each summer from the southern end of the peninsula, or perhaps from Cuba. This insect seldom appears farther north than southern Georgia. At times the damage is very severe, and often all of the plants in large fields are entirely defoliated. The moths usually make their first appearance in July in southern Florida, during August in central Florida, and during the last part of August or first part of September in the northern part of that State and in southern Georgia.

As little damage is done for the first 10 days or two weeks after the appearance of the moth, this insect should give no trouble when the early-maturing varieties of velvet beans are planted, as they will usually mature by the middle of September in northern Florida and southern Georgia.

The Florida Agricultural Experiment Station has been successful in combating this pest by dusting the vines with arsenate of lead or zinc arsenite 10 or 12 days after the first appearance of the moth. For this purpose 3 pounds of powdered arsenate of lead or zinc arsenite mixed with 12 pounds of air-slaked lime is sufficient for an acre. When this quantity is used there is no danger from poisoning the stock when pastured in the field, especially after one or two rains.

According to the Bureau of Entomology this insect is generally distributed throughout tropical America and has also been recorded as appearing in Mexico, Costa Rica, Panama, and Cuba.

SOME UNPUBLISHED DATA ON FEEDING VELVET BEANS.¹

By D. W. MAY, *States Relations Service.*

At the Georgia Experiment Station digestive trials were made recently with steers, testing velvet-bean meal alone and with silage and alfalfa hay as roughage. The results are shown in Table XVI

TABLE XVI.—*Digestion coefficients of velvet-bean meal fed alone and with silage and alfalfa hay.*

Method of feeding.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Alone.....	83.91	78.04	78.95	56.38	75.95	90.62
With silage ¹	77.42	78.51	64.03	65.33	71.11	84.67
With alfalfa hay ¹	79.52	75.48	63.56	67.62	75.17	86.98
With silage and alfalfa hay ¹	74.17	77.63	50.96	44.48	72.25	82.95
Average.....	78.76	76.92	64.38	58.46	73.62	86.31

¹ In these the digestion coefficients of the velvet-bean meal are determined by difference. The alfalfa and silage digestion coefficients are standards based on feeding-alone experiments.

With dairy cattle at the Tennessee station velvet-bean meal mixed with an equal amount of cottonseed meal in the beginning was taken with a relish. Later it was readily consumed alone as the entire grain ration. In no case, however, was it fed in greater amount than 10 pounds per head per day. In a preliminary test in feeding velvet-bean meal in comparison with cottonseed meal, 9 pounds of the former was hardly equal to 6 pounds of the latter.

From several experiments made by J. M. Scott in feeding velvet beans for milk production at the Florida station, the following results are noted. In the first experiment with velvet beans fed in the pod, milk was produced at 13.3 cents per gallon, as compared with 13.7 cents per gallon when cottonseed meal was fed. In the second experiment, with wheat bran used as a supplementary feed, the cost of producing a gallon of milk on the velvet-bean ration was 12.7 cents, and with a cottonseed-meal ration, 15.6 cents, the latter costing 22.8 per cent more than the former.

At the Tennessee station it was found that, with hogs, velvet-bean meal (pods and beans) could not well make up more than one-third the ration. Fed alone it was unpalatable to them.

¹ This compilation of the feeding value of velvet beans was prepared from unpublished data generously supplied to the Office of Experiment Stations by the experiment stations of Georgia, Tennessee, Florida, and South Carolina upon the request of the Agriculture Committee of the National Research Council.

The South Carolina station reports that pigs on a ration of two-thirds velvet-bean meal and one-third corn meal made a gain during the experiment of 77 pounds, an average of 0.916 pound daily, at a consumption of 4.68 pounds of the ration per pound of gain and a cost of 8.89 cents per pound.

At the South Carolina station a ration of two-thirds velvet-bean meal and one-third corn meal was compared with one of two-thirds soy-bean meal and one-third corn meal for fattening hogs. With the former 4.68 pounds of the feed made 1 pound of gain, while with the latter 7.24 pounds of feed was required per pound of gain. With the velvet-bean meal the animals gained 0.916 pound per day at a cost of 8.89 cents per pound. With the soy-bean meal the average gain per day was 0.548 pound at a cost of 13.97 cents per pound.





TRACTOR EXPERIENCE IN ILLINOIS

A STUDY OF THE FARM TRACTOR UNDER CORN-BELT CONDITIONS

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FARMERS' BULLETIN 963

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Office of Farm Management

W. J. SPILLMAN, Chief

Washington, D. C.

June, 1918

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THE GAS TRACTOR as a farm machine has already proved very valuable under many conditions, though it is still in process of development, and types change from year to year. As the tractor has not yet assumed a fixed place in general farm practice, the prospective purchaser may have difficulty in determining whether his conditions justify the expenditure, and if so what size of machine he should buy. The experience of more than 600 Illinois tractor owners, set forth in this bulletin, should help the corn-belt farmer in obtaining answers to his questions regarding advantages and disadvantages of the tractor, size of machine required, original cost, cost of operating, length of life, kind, quantity, and quality of work performed, and other vital questions.

TRACTOR EXPERIENCE IN ILLINOIS.

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CONSTANTLY increasing numbers of inquiries regarding the value of the gas tractor for farm work are received by the Department of Agriculture from farmers in all parts of the country. To meet this demand for information the Office of Farm Management has obtained thousands of detailed reports from tractor owners in all sections of the country, showing just what is being accomplished by these outfits in actual service on farms. Farmers' Bulletin 719, "An Economic Study of the Farm Tractor in the Corn Belt," was based on reports obtained early in 1916 from more than 200 tractor owners in the State of Illinois, but it is deemed expedient now to present what is essentially a revision of that bulletin, based on detailed reports received from 359 tractor owners in Illinois during the summer of 1917, and from 284 in the spring of 1918, thus bringing the information more nearly up to date. The aim is to present what are considered to be, from the farmer's standpoint, the more important facts and figures brought out in the reports of experienced tractor users.

Though the figures contained herein apply to conditions as they existed in Illinois in the summer and fall of 1917, in general they should be applicable, not only in Illinois, but throughout the corn belt, since the farms from which the reports used in this bulletin were received are typical in most respects of corn-belt conditions.

It should be understood clearly that these figures represent average results obtained in actual service and not the maximum possibilities of the tractor. These averages are believed to be worth more to a farmer in determining the possible value of a tractor for his work

than are maximum figures from tests, no matter how carefully conducted. The latter would represent, at best, only a limited number of machines operated under especially favorable conditions, while the averages here given represent a large number of machines operated by incompetent as well as by competent operators, and under actual service conditions which it is exceedingly difficult to duplicate in tests. A prospective purchaser may reasonably count upon equaling the average performance of his neighbors. He should strive, of course, to equal the maximum performance of experts, but should not depend upon being able to accomplish such results in order to justify investing in a tractor. For example, an outfit with sharp, new plows, operated by an expert, may plow an acre of ground with, say, 1 gallon of gasoline, but since, under ordinary conditions, with plows that have been sharpened several times and perhaps are not in perfect adjustment, the fuel consumption will ordinarily equal at least the average given herein ($2\frac{1}{2}$ gallons), it is obvious that the farmer should use the average figure in determining the possible value of the tractor for this work, rather than the exceptional figure.

This bulletin is not intended to influence the farmer either for or against the tractor as a source of power, but only to assist him in determining whether his individual conditions justify the use of such power. The question whether a tractor will prove profitable on a particular farm is a problem in farm management which must be worked out for that individual farm. Judging by the reports of owners, however, it will prove profitable on most corn-belt farms of 180 acres or over, while in the opinion of these men it should not be expected to do so on farms of much less than 130 acres. It is believed that consideration of the various influencing factors mentioned in the following pages will be of material assistance to farmers in deciding whether a tractor will prove a wise investment on their own farms.

CORN-BELT CONDITIONS.

Corn is the principal crop grown on practically all these farms, approximately 40 per cent of the entire acreage being planted to this crop. Oats are raised in most cases, the acreage averaging about one-half as great as for corn. The next crop in point of acreage is wheat, which is raised to a limited extent on more than half of the farms. Hay, including alfalfa and clover, forms a large percentage of the remaining crops. Both spring and fall plowing are practiced, slightly more ground being plowed in summer and fall than in the spring. The land is mostly level or gently rolling, in general quite free from stone, and while there is a good deal of rather heavy loam, the plowing conditions are not severe, except when the ground is very dry. The fields are generally regular in shape and range in size from about 20 acres up.

The above-mentioned facts relative to the general characteristics of the type of farming followed should be kept in mind when considering the figures furnished by tractor owners in this section.

DATA FOR 1917-18 COMPARED WITH 1916 DATA.

Probably the most significant difference between the reports received from the tractor owners in 1917-18 and those received in 1916 is the much larger percentage of men who reported that the tractor had proved a profitable investment. In 1916 less than 80 per cent reported that the tractor had proved a profitable investment, whereas in 1917 and 1918, 90 per cent, or 9 out of 10 men, made such reports. This is partly due to the improvements which have been made in the tractor, and partly, of course, to the increased prices commanded by both farm products and farm labor during the past year. In this connection, however, it should also be noted that while in the beginning of 1916 a considerable number of the large old-model tractors commonly used five or six years ago were still in use, by the end of 1917 practically all of these machines had been discarded, and the reports on which this bulletin are based deal almost without exception with the small or medium-sized tractors which have been developed during the last three or four years, and which not only cost less in the first place, but give every indication of having a longer life and lower repair charges than the older models.

Another significant difference between 1918 and 1916 is the increase in the percentage of 3-plow outfits and the decrease in the percentage of 2-plow outfits in use, which is in keeping with the opinions of tractor owners set forth in Farmers' Bulletin 719, to the effect that the 2-plow outfit is not large enough for the average corn-belt farm, and that the 3-plow or 4-plow machines are better adapted to the conditions in this section.¹

Nearly three-fourths (71 per cent) of all the tractors in Illinois of which reports were received in 1917-18 were pulling 3 plows, while more than three times as many 2-plow as 4-plow machines were in use. The recommendations of the owners of these machines as to the best size of tractor for their particular farms show that only 11 per cent recommend 2-plow machines, while 13 per cent advocate the use of 4 plows, and the remaining 76 per cent, or more than three out of four men, advise the 3-plow size.

¹ In all cases the size of tractor is referred to by the number of 14-inch plows pulled rather than by the horsepower ratings. This is done because manufacturers do not use a uniform method of rating their outfits, and a comparison of different tractors by their horsepower ratings is practically valueless. It is believed that grouping by the number of plows pulled, under conditions which are not only fairly uniform but which represent average conditions, offers a more reliable comparison than would be obtained by grouping according to the horsepower ratings.

ADVANTAGES AND DISADVANTAGES OF THE TRACTOR.

The theoretical advantages of mechanical power for farm work are obvious, but to the prospective purchaser of a tractor the important thing is to know what the men who have used tractors have found to be their principal advantages and disadvantages in actual practice.

Several hundred Illinois tractor owners were asked the questions: "What do you find to be the principal advantages of a tractor for farm work?" and "What are the principal disadvantages?" In the replies to these questions the same points are emphasized as were mentioned in Farmers' Bulletin 719.

The ability of a tractor to do heavy work and do it quickly, thus covering the desired acreage within the proper season, is considered the principal advantage. The saving of man labor and the doing away with hired help, enabling a man to farm a larger acreage and thus increase the crops he can raise, is next in importance. The ability to plow to a good depth, especially in hot weather, is also emphasized, while other points are mentioned occasionally, but not in a sufficient number of cases to warrant listing in this connection.

The availability of the tractor for work at night as well as by day was not mentioned by many owners, although theoretically this should be a decided advantage.

Under disadvantages, the difficulty of efficient operation is the principal point, and this fact should be kept in mind by everyone who considers the purchase of a tractor. (See "Operation," p. 24.) Packing of the ground when damp is mentioned by several owners, but not as frequently as was the case when more of the older and heavier machines were in use. Expensiveness, delays, and inability to use the tractor for many kinds of work for which horses could be used are disadvantages mentioned by several owners. Other disadvantages are noted, but not by a sufficient number to warrant mentioning here. It may also be noted that disadvantages are not emphasized to so great an extent as formerly, nor in nearly so many cases as advantages.

SIZE OF FARM AND TRACTOR.

Though the introduction of an improved farm machine may be expected to reduce the man labor required for farm operations, thus permitting one man to accomplish more work and so farm more land than with the older methods, it is obvious that a farm business must be of sufficient size to permit the economical use of an improved machine in order to justify the necessary investment. That is, many small farms must either use the old methods or hire a modern outfit, because the small amount of work to be done each year does not warrant owning the machine.

Among the more important facts disclosed by a study of the use of the tractor for farm work are those relating to the increase in the acreage which can be farmed by one man when a tractor is used in connection with horses, over that farmed with horses alone. Approximately one-third of all the Illinois farmers reporting increased the acreage they were farming after purchasing a machine, the percentage of men so doing being slightly higher in the group reporting the tractor profitable. The percentage of the entire number of tractor owners who have enlarged their farms is significant, for whereas there has been a tendency for the size of corn-belt farms to increase in recent years,¹ the increase among farms in general is not nearly so pronounced as in the case of farms on which tractors are used.

Farm-management studies repeatedly have demonstrated the fact that a great many farms are not large enough to furnish economical employment for the equipment which they possess. That is, the various implements are capable of doing the work on a larger acreage within the time which the seasons allow, and the purchase or renting of additional land often will increase the gross receipts considerably without materially increasing the operating expenses. This increase in the size of farms upon which tractors are used is merely another proof of the fact that the use of improved farm implements increases the amount of land one man will farm.

With the tractor, as with any other farm machine, it is important that a suitable size should be selected for a given acreage. A few years ago there was a wide range in the sizes of tractors on the market (outfits pulling from 2 to 14 plow bottoms being sold), but there has been a decided tendency during the last year or two to reduce materially this wide range in size, and by far the largest percentage of the tractors sold at this time pull either 2, 3, or 4 plows, with the 3-plow size much the most numerous. For several reasons the large outfits did not prove successful or economical under ordinary farm conditions, and for a short time the tendency was strong to go to the other extreme, most of the tractors produced and sold for a short period being 2-plow machines. However, during the last two years, and especially during the 1917-18 season, the tendency has been toward a somewhat larger tractor, with the result that three-fourths of all machines studied in Illinois in 1917-18 were 3-plow or 4-plow outfits, with the 3-plow size predominating.

It is doubtless as a result of the more general use of the 3-plow and 4-plow machines, and hence a better acquaintance on the part of farmers with these sizes, that 76 per cent of all owners reporting recommend the 3-plow machines, while 13 per cent favor the 4-plow

¹ U. S. Census, 1910, Vol. V, p. 276.

outfit, and only 11 per cent advise a 2-plow rig, whereas, at the time the data on which Farmers' Bulletin 719 was based were collected (1916), a somewhat greater percentage of tractor owners recommended the 4-plow than the 3-plow outfit, with 13 per cent advising the 2-plow rig. At present there seems to be no doubt that the 3-plow size is the general favorite for corn-belt conditions, whereas the 4-plow is more generally preferred than the 2-plow size.

Even on farms of comparatively small size the 3-plow tractor is recommended by the largest percentage of owners. This, taken with the other facts, seems to indicate that the 2-plow tractor does not increase sufficiently the amount of work which one man can do, hence does not possess, except to a slight degree, the greatest advantage of tractors in general, namely, timeliness in performing farm operations through much more rapid work than is possible with horses. Moreover, a 2-plow tractor does not ordinarily develop enough power to make it suitable for operating grain separators, ensilage cutters, etc., which are tasks for which power is required on the average corn-belt farm. It happens not infrequently that the owner of a 2-plow tractor has to hire an engine with slightly more power to do his belt work, so it is not to be wondered at that in case he were buying another machine he would select one with more power.

The question as to the smallest size of farm on which a tractor may be expected to prove profitable is one often asked and one that has been much discussed. Certainly no more reliable opinion on this point could be obtained than the average of the estimates of a large number of tractor owners. In the opinion of these men the minimum number of acres on which 2-, 3-, or 4-plow outfits may be expected to prove profitable are 130, 170, and 210 acres, respectively.

Attention is called especially to the fact that these figures represent the *smallest* size of farm for which these tractors should be purchased, in the opinion of men who have had experience with them, and not the size on which they can be used most profitably. A farmer who is contemplating the purchase of a tractor and whose farm is smaller than the acreages above given should consider carefully before acting contrary to the opinions of experienced men.

While a tractor is less efficient on a small farm, because of the smaller fields and a correspondingly greater loss of time in turning, larger percentage of the area of fields to be finished up with horses when plowing, etc., these points are not so important as the fact that the small farm is usually thrown out of balance, from an economic standpoint, by the investment of a disproportionate amount of capital in power which can be used fewer days than would be the case with the same machine on a larger farm. The overhead charges per unit of work done are, therefore, much higher on the small farm. The obvious course for the small farmer who has already invested in a

tractor is to acquire more land in order to utilize the tractor more efficiently, which, as mentioned elsewhere, is the course followed by a large percentage of tractor purchasers.

The average sizes of the farms reporting on which 2-, 3-, or 4-plow tractors are in actual use are considerably above the minimum figures given above, being 180, 250, and 300 acres, respectively.

To obtain the fullest degree of satisfaction it is necessary that the proper size of tractor be bought. A tractor which is not powerful enough for the work required of it will prove more or less unsatisfactory, of course, and to exchange it for a larger one entails an expense which would be unnecessary if the right size were obtained in the first place. On the other hand, an outfit which is much too large may be too clumsy or expensive in operation to make it economical for a great deal of work on which a tractor of the proper size could be used with satisfaction and economy.

The 3-plow and 4-plow sizes seem to meet best the tractor requirements of the average farm in Illinois; they enable plowing to be performed much more rapidly than is usual when horses are employed. The man labor is also reduced when using these sizes of tractors, as one man attends to 3 or 4 plows at one time, instead of only 2, as is ordinarily the case where horses are used. (Where modern self-lifting gang plows are used, one man ordinarily handles the entire outfit in plowing, no matter what size gang is used.) Furthermore, the 4-plow size of tractor is generally powerful enough to operate practically all of the machines which are commonly found on the average farm, including the ensilage cutter and the medium-sized grain separator. At the same time it is not so expensive in operation as to prohibit its use for many odd jobs which do not demand a great deal of power.

In purchasing an outfit care should be exercised to obtain one with ample power for the heaviest work which will be required of it. This may be either field work or belt work; probably it will be the latter more often than the former. Frequently the work of a tractor in driving a grain separator or ensilage cutter requires more power than the plowing, and in such cases the tractor bought should be powerful enough to handle the belt work properly. On the other hand, if the belt work which will be required of the tractor will not demand a great deal of power, while there may be a considerable amount of plowing which it will be desired to complete within a limited season, the tractor should be capable of pulling enough plows to enable the work to be performed within the time available.

Then there are cases where only a small amount of belt work is required, and most of the field work will be done with horses, the tractor being wanted merely to make extra power available in rush seasons, or to relieve the horses during hot spells. In such cases the

small 2-plow outfits frequently have proved most satisfactory. Such an outfit has the advantage of not necessitating a large investment and on this account is frequently recommended by experienced men as a good size to buy at first in order to gain experience in the use and care of tractors.

If it is desired to use the tractor for custom work on neighboring farms or for road work, care should be exercised to choose an outfit with sufficient power to handle such work satisfactorily.

As a general rule it is better to err through buying an outfit with too much power rather than too little, but this should not be interpreted as recommending the purchase of the largest sizes. It refers rather to the apparently too-common practice of getting a 2-plow outfit to do work which should properly be done with a 3-plow or 4-plow machine.

COST OF TRACTOR OUTFIT.

While the cost of a tractor should not be the only consideration, it is one of the first points which a farmer must consider. The prices of the various makes of outfits vary considerably for machines of practically the same capacity, owing to difference in quality, sales systems, efficiency in manufacture, quantity produced, etc. It is a grave mistake to sacrifice quality for a saving in the first cost, since there is no other farm machine in which reliability and serviceability count for more than in the tractor. On the other hand, it is poor management for a farmer to invest too large a part of his capital in power. The desirability of further standardization and quantity production of tractors, in order to reduce the first cost, is obvious.

The price which a farmer can afford to pay for a tractor for use on his farm depends upon a number of factors, such as the amount and value of the work which the machine will perform annually, the value of the horses which it will displace, the value of the man labor saved, and the amount of increased returns which reasonably may be expected from its use.

The prices for both tractors and the implements for use with them have been considerably increased during the last two years, owing to the advances in costs of both labor and materials required to produce them. The prices paid for the three sizes most commonly bought during 1917 on the Illinois farms reporting averaged about \$800 for the 2-plow, \$1,100 for the 3-plow, and \$1,400 for the 4-plow machine, while the prices for the plows for use with them averaged about \$115, \$165, and \$235, respectively. In all cases the prices, of course, varied considerably according to the make and quality of the machines. At the beginning of 1918 there was a further general and substantial increase in prices.

LIFE OF THE TRACTOR.

The amount of service which a tractor will perform before it must be replaced is obviously an important factor in determining its value for farm work.

Gas tractors have been on the market for such a comparatively short time, and have undergone so many changes in their process of development, that it is impossible to obtain any really definite figures as to the amount of work a tractor of modern design reasonably may be expected to do before it must be replaced. There are several factors which have considerable influence on the amount of service rendered by a given machine, by far the most important of which is the care it receives at the hands of the operator. (See "Operation," p. 24.) The quality of the outfit, the kinds of work for which it is used, and the conditions under which it is operated will all materially affect its life.

Nearly all tractors are used under conditions which are extremely severe for any kind of machine. They travel over rough and uneven ground, and are subjected to severe shocks both from obstructions in the path and from the load being pulled. A still more injurious condition is their exposure to an almost constant shower of dust and dirt, which, if the soil contains much gritty substance, attacks all gears and bearing surfaces, not only those on the exterior of the machine but also those inside the engine itself, unless an efficient filter is provided for the air intake to the carburetor. This excessive wear due to dust was a very serious matter with the earlier models of tractors, but many manufacturers have made great progress during the last year or two in protecting their machines in this respect.

It is obviously impossible to determine definitely the probable life of the latest model tractors, since none of them are worn out, but the nearest approximation to the actual figure would unquestionably be the average of the estimates given by a large number of men who had used them for a season or two, and who should be in a position to give a fairly reliable opinion as to the additional service that reasonably may be expected from their machines. Tractor owners were asked for an opinion as to the number of years their own particular machines would give satisfactory service, and also to give an estimate of the average life of farm tractors. The replies to these questions showed a tendency on the part of men who reported the tractor as having been profitable to estimate that their own machines would last somewhat longer than the average machine. On the other hand, men reporting them unprofitable usually gave the probable life of their machines as less than their estimate of the average life of tractors in general. The answers to both questions, however,

averaged very nearly the same, being eight and seven and one-half years, respectively.

Of course, these averages can not be regarded as being absolutely accurate, but certainly they should be as nearly accurate as any figures which could be obtained in any other manner at the present time. As a matter of fact there would probably be a tendency on the part of tractor owners to overestimate somewhat. (See "Repairs," p. 13.) It is not believed, however, that a prospective purchaser of a tractor should expect for his outfit a longer life than seven and one-half seasons, and he would be on the safe side if he counted on a somewhat shorter period of service when calculating the probable value of a tractor for his work.

DAYS USED ANNUALLY.

It is obvious that the life of a tractor can not be expressed definitely in terms of years, since the number of years it will last will depend upon the amount of work done each year; that is, the number of days or hours it is used. This varies on different farms, according to size, type, and system followed, as noted under "Life of the tractor" (p. 11), the average for tractors in Illinois being 45 days per year.

While at first glance this may appear low, when it is remembered that on farms where horses do all the work they are used on an average of only about 100 days annually, it will be seen that where both horses and tractor are used, even though the number of horses is somewhat reduced, the machine need not be expected to have employment for as many days annually as did the horses. The horses kept will still do some of the work, which will, of course, decrease the amount to be done by the tractor. A considerable percentage of the 100 days' work done by horses represents odd jobs for which the tractor can not be used to advantage. Even if the machine were to do all the work formerly done by the horses, it would not normally be employed 100 days per year, inasmuch as it does the work more rapidly.

It should be borne in mind that practically all farm operations must be carried on within limited periods, and that between these seasons there will often be no field work which the tractor can do, either on the home farm or for neighbors. The fact that weather and soil conditions are such as to permit field work with a tractor does not necessarily mean that there is such work to be done. Farm management plays an important part in organizing the farm so as to provide profitable employment for the tractor during as many days as possible. Such organization involves the planning of a crop rotation which will furnish a large amount of work which it can do, the elim-

ination of as many horses as desirable, and the distribution of the work over a long period. However, the rotation should include only such crops as can be grown profitably in that particular section.

The significance of the fact that a large percentage of these Illinois farmers enlarge their farms after buying tractors is readily apparent when the tractor's place in farm management is thus considered. Obviously these men have learned through experience that much more land per man can be handled when a tractor is used than with horses only, and that to get the most out of their investment they must farm land enough to keep their tractors busy at profitable work throughout as much as possible of the available working season.

REPAIRS.

Any figures on the expense of keeping a tractor in repair are of necessity very general. The amount of repairs required depends upon a great many factors, the most influential being the proficiency of the operator and the care he gives the outfit, both when in use and when idle. The conditions under which the outfit is used, that is, whether on rough ground, in dusty fields, etc., the load it is required to pull, and, of course, the quality of the machine itself, all have an effect on the repair bills. Many tractors are kept in repair by the manufacturer during the first year's service, excepting for such items as are caused by some fault of the operator. It is not until the second year, therefore, that the owner bears the full expense.

Of 140 tractor owners in Illinois who had used their outfits one season or less (average age 9 months), 48 reported that they had spent nothing for repairs. The others had repair bills varying from a few cents to a hundred dollars or more, the average being \$22, making the average repairs for the entire group about \$15. Comparatively few machines go through their second season without repair charges. The average repairs for 158 Illinois outfits between the ages of 13 and 24 months (average age 20 months) was \$39. For 34 machines between the ages of 25 and 36 months (average age 32 months), the average repairs amounted to \$79.

The statement is frequently made that a tractor should last indefinitely with proper repairs, since all parts are renewable and the substitution of new parts for worn ones will make the outfit as good as new. The same arguments are often advanced with regard to automobiles, but everyone knows that it doesn't hold true in that case, nor does it with the tractor. In both cases, as with practically all other machines, there comes a time when so many parts have become worn and need replacing that the cost of repairs is so great as to make it unwise to spend such an amount on an old machine, it being more profitable to discard it and buy a new one. Furthermore, it becomes

increasingly difficult to obtain repair parts for any machine as years go by. Not infrequently a manufacturer goes out of business or discontinues the production of a particular machine, thus making it impossible, or at least very expensive, to obtain extra parts. It seldom pays to attempt to use badly worn machines where the farming system provides work for the labor and equipment during most of the working season, since such outfits may cause serious delays and a direct or indirect money loss equal to the cost of a new machine. This is especially true of the tractor.

It is impossible at present to state definitely just what effect the size of tractor has upon the repair bills. The figures thus far obtained would seem to indicate that the percentage of the first cost required annually for repairs is somewhat lower for the 4-plow size than for the smaller outfits, but this may be due to the fact that there are more cheaply constructed and low-priced outfits among the smaller sizes than among the 4-plow machines. It is impossible as yet to make any definite statement as to the annual repairs required by high-priced machines as compared with lower-priced ones of the same capacity. The figures seem to indicate that repairs are somewhat lower for the high-priced machines, but there is not enough difference to justify a positive statement to this effect.

The figures given would indicate an annual repair charge during the first three years of a tractor's life of about 3 per cent of the first cost, but this would undoubtedly increase during the latter years of its life, as is the case with most other machines. It would not seem safe to expect the cost of repairs for a tractor to average less than that for other farm machines, which is a little over 4 per cent,¹ and it is not improbable that it will amount to slightly more than this. In figuring the repair costs to be charged against each day of use or acre plowed, the average annual charge has been taken as 4 per cent of the first cost.

WORK DONE PER DAY.

PLOWING.

The number of acres covered per day by a plow drawn by a tractor is usually slightly greater than that covered by the same-sized horse-drawn plow. The acreage covered by two different machines, each pulling the same number of plow bottoms, often varies considerably, because they travel at different speeds, are in different kinds of soil, plowing different lengths of furrows, etc. Theoretically a 14-inch plow when drawn by a tractor should cover approximately 3 acres in an ordinary working day of 10 hours, as the average plowing speed is slightly more than 2 miles per hour. This will hold true in

¹ U. S. Department of Agriculture Bulletin 338.

actual practice when the plowing conditions are favorable, provided the outfit does not give trouble. That is, a 2-plow machine should plow 6 acres and a 10-plow outfit 30 acres per day, provided both travel at the average rate of speed and are kept moving. However, where trash is to be turned under which frequently clogs the plows, each plow drawn by a large tractor will cover much less ground in a day than one drawn by a small outfit, since the delays will naturally be in proportion to the number of plows pulled. A delay on account of one plow on a 2-plow outfit stops only 1 other plow, while on a 10-plow rig, for example, it stops 9 other plows. To illustrate: Supposing a man operating a 2-plow tractor were compelled to stop 10 times during a day for each plow in order to clear it of trash, and spent three minutes each time (which would not be unusual), the loss of time during the day would amount to a half hour for each plow or but one hour total loss. Each plow would have done nearly as much work as in plowing continuously. On the other hand, a man operating a 10-plow tractor under the same conditions would have to clear each plow the same number of times in proportion to the acreage covered, resulting in a total loss of three or four hours during the day. In such case each plow would have done much less work than under favorable conditions.

In view of these facts it is apparent that when plowing under unfavorable conditions large gang plows do not cover as much ground per day per plow as the smaller ones. However, one man accomplishes considerably more work with the large outfits, even under such conditions.

According to the figures furnished by tractor owners in Illinois the area covered per day (10 net working hours) in plowing with the tractors most commonly used is $6\frac{1}{2}$, $8\frac{3}{4}$, and 10 acres for the 2-, 3-, and 4-plow outfits, respectively. These figures for the 2-plow and 4-plow outfits correspond quite closely with the averages shown in Farmers' Bulletin 719 for the same sizes of tractor, while the average acreage covered by the 3-plow rigs shows an increase of one-half acre per day. This is doubtless due to the placing on the market of a large number of 3-plow outfits of slightly greater power, and therefore larger capacity per day, than the 3-plow machines in use when the data for Farmers' Bulletin 719 were obtained.

In this connection it should be noted that many tractor owners require their outfits to pull one more plow than they are rated to handle. Under such a load the outfit does not cover as much ground as would be covered by a machine built to pull that number of plows. Three plows behind a 2-plow tractor will cover only a little more ground, as a rule, than will the 2 plows, because the tractor usually will travel a little slower, partly because the motor is overloaded and does not maintain its proper speed, and partly because the drive

wheels will slip more than usual with a load heavier than the machine was designed to pull. As a consequence delays on account of small holes or slight grades will be more common, as will also mechanical difficulties.

The reports of a number of men who were thus overloading their machines were tabulated and compared with the results obtained by other men who owned the same make and size of tractor, but who were requiring their machines to pull only their normal loads. This comparison showed that the repairs on the overloaded tractors were considerably higher, more time was lost per day with these outfits, and the estimated life of the overloaded tractors was considerably less than for the machines pulling normal loads. At the same time the increase in ground plowed amounted to only about $1\frac{1}{4}$ acres per day; that is, the additional plow covered about one-half as much ground in a day as did each of the two plows which constituted a normal load. The gasoline consumption per acre averaged somewhat lower for the overloaded machines, as would naturally be expected, since the tractor would not have to travel so far to plow an acre. However, the depth plowed was not so great, and it is reasonable to suppose that the plowing conditions were generally favorable or the third plow would not have been tried. The increased acreage per day and the slight saving in fuel together would not offset the increased repairs and the value of the time wasted from trouble with the outfit. Overloading a tractor is inexcusable save in exceptional cases where speed in completing a job is of the utmost importance. If such speed is required regularly the work could be done more cheaply and satisfactorily with a larger outfit.

OTHER WORK.

The acreage covered per day at field operations other than plowing will vary, of course, with the width of the implement pulled, and this in turn will depend upon the relative draft. It is therefore impossible to give for such operations average figures which would be of value. In harrowing or disking, for example, the width of the implement pulled will depend upon the adjustment of the disks or harrow teeth and the depth of the ground being worked. It is perhaps unnecessary to state that the nature of the soil will also have an influence. The speed of the tractor ordinarily will not be quite as great in soft ground as where the machine has a firm footing, because of the greater slippage of the wheels. On the whole, not so much time is lost on account of clogging or other obstructions when harrowing, disking, etc., as when plowing.

The approximate acreage covered in a day of 10 hours with implements of different widths can be determined easily by allowing about 2 acres per day for each foot of the implement's width where the

outfit is working on soft ground. Where it has a good footing it may be safe to allow $2\frac{1}{2}$ acres for each foot of the implement's width. The acreage covered, of course, will vary with different machines, owing to the different speeds, but the figures given are based on a speed of 2 miles per hour, with an allowance for time lost in turning and the slight overlapping which occurs to a slightly greater extent in most other field operations than in plowing.

By far the largest proportion of the work done by tractors is in plowing and preparing the seed bed and in belt work. While they are used for a number of odd jobs at different times, these represent an insignificant portion of the total work. Hauling, which usually occupies farm horses for several days annually, is not commonly undertaken with the tractor, and in most cases where it has been tried it has been found less satisfactory and more expensive than horses. To make an economical load for the tractor it is necessary to have several heavily loaded wagons, and this makes an unwieldy outfit in turning corners and in getting in and out of loading and unloading places in most towns and villages. Other objections to the use of the tractor for hauling advanced by men who have tried it are the heavy wear and tear on both tractor and wagons on hard roads, expense on the unloaded return trip almost as great as when loaded, and difficulty in handling heavy loads on grades. It is not surprising, therefore, that only about 20 per cent of tractor owners report doing hauling with their outfits and that on the whole it represents less than 4 per cent of the work done by the tractor.

COST OF OPERATING.

Probably the one point in which the prospective purchaser of a tractor will be more interested than in any other will be the cost of performing farm operations with the tractor. This cost is made up of four main factors, namely, *operating expenses* (including fuel, oil, and grease), *repairs*, *depreciation*, and *cost of man labor*. In addition there will be some less important charges, such as interest on the investment, cost of housing, time spent in caring for the outfit other than repair work, etc.

When calculating cost of tractor work the mistake should not be made of omitting any of the first four items, as each of them will amount to considerable per unit of work. The others may be comparatively insignificant in some cases, although they must be included to obtain a strictly accurate figure.

In order to give the prospective purchaser an idea of the average cost of using a tractor, the following figures for the sizes most commonly used have been compiled. From the facts given it is believed that a farmer can approximate the costs for any other size in which he may be interested.

FUEL COST.

The average quantity of fuel consumed per acre in plowing for all tractors on Illinois farms reporting is $2\frac{1}{2}$ gallons. This figure does not vary materially for the different-sized outfits, so long as each pulls its normal load. It is possible, however, to reduce the fuel consumption somewhat by overloading the tractor; that is, adding one more plow bottom than the machine is intended to pull. This, as pointed out already, reduces the distance the machine must travel to plow an acre, and, consequently, results in a slight saving of fuel. The saving is not in proportion to the actual distance traveled, however, since with the overload there is much more slippage of the wheels and consequent loss of power.

There is some slight difference in the fuel consumption between different makes of machines, and also usually a slightly lower consumption in some makes of tractors where gasoline is used instead of kerosene. These differences, however, do not usually amount to a great deal, and for most purposes the figure of $2\frac{1}{2}$ gallons of either gasoline or kerosene per acre of plowing will be as nearly accurate as any that can be used for an average.

The investigation shows that less difficulty is being encountered by owners of kerosene tractors in burning the lower grade of fuel than was indicated in 1916. Slightly more than 50 per cent of the tractors on the Illinois farms reporting are operating on kerosene, and where the machines have been especially designed to burn this fuel the results are apparently very satisfactory, particularly in view of the present price of kerosene as compared with gasoline, the former costing only about one-half as much as gasoline. However, the greater ease in operating on gasoline, and the somewhat greater certainty of steady operation, are sufficient to cause many men to prefer this fuel to kerosene. The fuel consumption, of course, varies considerably, even with the same make of machine and under practically the same conditions, when driven by different operators, as a proficient operator will be able to make such adjustments as will reduce the fuel consumption to the minimum, whereas an inefficient operator will frequently run the outfit in such a manner as to increase unduly the amount of fuel used.

In this case, as in others, a prospective purchaser is not safe in assuming that he can obtain better results than the average, although of course he should endeavor to do so. In making calculations it is always best to be on the safe side. The average price paid for gasoline by the Illinois tractor owners in 1917 was about 20 cents per gallon, and for kerosene slightly less than 10 cents per gallon. With these prices, therefore, the fuel cost per acre for plowing with the tractor averaged about 25 cents where kerosene was used and 50

cents where gasoline was used, not making any allowance for warming up the kerosene engine with gasoline. All kerosene tractors start and warm up on gasoline, but the quantity used for this purpose varies greatly with different makes and with different operators. The quantity of gasoline required for this purpose is in most cases less than 1 gallon per day, and the extra cost for gasoline will usually not exceed 10 cents per day, and should seldom be more than 1 cent per acre plowed.

LUBRICATING OILS.

The quantity of lubricating oil used per acre with different outfits showed a much greater variation than the fuel required. Some men reported using nearly a gallon of lubricating oil per acre, while many reported less than 1 pint per acre. The quantity used will, of course, vary somewhat with the different makes of machines, but the greatest variation will be due to the idea of the operator as to the quantity with which the engine should be supplied.

It is usually false economy to cut the quantity of oil down too low, but on the other hand it is easy to use more than is necessary and than will really be of benefit. The average quantity of oil per acre used in plowing, for all tractors reported from Illinois, was about three-fifths of a quart. With oil at 35 cents per gallon (the average price paid for it), this would amount to $5\frac{1}{4}$ cents per acre. The kind of fuel used does not seem to make any decided difference in the quantity of lubricating oil required.

GREASE.

The quantity of grease, or "hard oil," used also varies widely with different machines and different operators. No attempt to obtain definite figures on this point was made, as it is of such minor importance that few farmers pay much attention to the quantity used. It is not believed that the consumption will amount to 1 pound per day on the average, and the cost is usually in the neighborhood of 10 cents per pound, thus making the cost of this item amount in most cases to less than 2 cents per acre. At any rate, 2 cents per acre would be a reasonable figure.

TOTAL FOR FUEL AND OIL.

Based on the figures given above for the Illinois farms reporting, the average cost per acre plowed for gasoline, oil, and grease is about 57 $\frac{1}{4}$ cents where gasoline is used, and 32 $\frac{1}{4}$ cents where kerosene is used.

REPAIRS.

Using the figures given under "Repairs" on page 14, and under "Days Used Annually" on page 12, i. e., the average annual repair charge as 4 per cent of the first cost, and the days used annually as

45, the average repair charge per day for the 2-, 3-, and 4-plow outfits of average price would be 71 cents, 98 cents, and \$1.24 per day, respectively. For the average acreage covered with these different-sized rigs, the repair charge per acre would therefore be 11, 11, and 12 cents, respectively.

DEPRECIATION.

Assuming the average life of a tractor to be $7\frac{1}{2}$ years (see p. 12), the average annual depreciation on the 2-, 3-, and 4-plow outfits will be \$106.67, \$146.67, and \$186.67, respectively. The daily charge, therefore, based on 45 working days per year (see p. 12), will be \$2.37, \$3.26, and \$4.15, respectively.

The depreciation cost per acre, based on the average acreage plowed by the different-sized outfits, as shown on page 15, will be 36 cents, 37 cents, and 42 cents, respectively. From these figures it will be seen that the depreciation charge is one of the largest items which go to make up the total cost of performing work with the tractor, yet it is one which many people ignore entirely when figuring tractor costs. In this case, too, a rather long life has been used, which makes the depreciation somewhat lower than would be altogether safe to count upon. (See p. 12.)

The cause of the depreciation cost for the 4-plow machines being so much higher per acre than that for the smaller rigs is that the 4-plow machines in use up to the present time have cost more in proportion to relative working capacity than in the 2-plow and 3-plow rigs, owing partly to the fact that the smaller sizes have been manufactured in larger quantities, thus reducing the cost of production, and partly to the fact, stated elsewhere, that fewer low-priced machines have been produced in the 4-plow size. This difference undoubtedly will decrease with increased production of the 4-plow outfits.

MAN LABOR.

Comparatively few of the Illinois tractor owners reporting hire operators, and in cases where the machine is operated by hired help the wages paid vary widely. Some men intrust their machines to ordinary hired hands at comparatively low wages, while others attempt to secure first-class operators and are willing to pay fairly high wages to secure thoroughly competent men.

The cost per acre for man labor will be considerably affected, of course, by the wages paid, although in many cases a high-priced operator may do enough more work per day partly to offset his higher wages, and by reducing operating and repair charges may much more than offset them. The greater reliability of the higher-priced operator and the consequent certainty of having the work done when desired also has a value, but this can not be calculated.

To ascertain the cost per acre for man labor in plowing with a tractor, in order to round out these cost figures, the cost for man labor has been placed at \$3 per day. This is about the actual cost for operators to many corn-belt farmers when cost of board, etc., is included. Using this figure, the cost per acre for man labor with the 2-, 3-, and 4-plow outfits, based on the average acreage given, would be 46 cents, 34 cents, and 30 cents, respectively.

INTEREST.

The interest charge on a tractor is a fixed annual charge, and the interest cost per unit of work obviously will vary with the number of days the tractor is used, decreasing as the number of days used increases. Figuring interest at 6 per cent on the average investment (one-half the first cost) for the different-sized tractors, as shown on page 10, and assuming the average number of days used annually to be 45 (see p. 12), the average interest charge per day for the 2-, 3-, and 4-plow outfits will be 53, 73, and 93 cents, respectively.

The interest cost per acre, based on the average acreage covered by the different-sized rigs, would therefore be 8, 8, and 9 cents, respectively. The fact that the acreage covered per day by the 4-plow outfit does not increase in proportion to its cost makes the interest charge per acre for this size higher than for either the 2-plow or 3-plow tractor. The increased acreage plowed per day by the 3-plow rig as compared with the 2-plow offsets the increased interest charge due to higher price. It should be borne in mind, however, that the number of days used annually will cause a variation in the interest charge per unit of work.

TOTAL COST PER ACRE.

PLOWING.

The approximate total cost for plowing an acre with a tractor under normal pre-war conditions, as calculated from the figures given in the preceding pages, would be as shown in Table I.

TABLE I.—Approximate cost of plowing an acre with 2-, 3-, and 4-plow tractors, based on average cost of \$800, \$1,100, and \$1,400, respectively, and a life of $7\frac{1}{2}$ years of 45 working days per year.

Size of tractor.	Total. ^a		Fuel.		Oil.	Grease.	Re-pairs.	De-precia-tion.	Man labor.	Inter-est.
	Gasoline tractor.	Kero-sene tractor.	Gasoline.	Kero-sene.						
2-plow.....	\$1.58½	\$1.33½	\$0.50	\$0.25	\$0.05½	\$0.02	\$0.11	\$0.36	\$0.46	\$0.08
3-plow.....	1.4½	1.22½	.50	.25	.05½	.02	.11	.37	.34	.08
4-plow.....	1.50½	1.25½	.50	.25	.05½	.02	.12	.42	.30	.09

^a The cost of housing the outfit and other minor overhead charges, such as taxes, insurance, etc., are not included.

OTHER OPERATIONS.

From the figures given above it will be a comparatively easy matter to arrive at relative costs for other operations with the tractor. For all field operations the daily charges for interest, depreciation, and man labor will, of course, be about the same, but must be divided by the acreage covered by the implement used. This acreage will vary with different implements. The fuel and oil charge will be the same for a 10-hour day in other field operations as in plowing, provided the tractor is loaded to the same extent. This, however, is frequently not the case. If a comparatively light load is drawn, the fuel and oil consumption will be somewhat reduced, but not in proportion to the load. For stationary work, if the engine is working to full capacity, the fuel and oil charges will be approximately the same as for a day's work in plowing, but no grease will be used on most machines. This, however, would be only a small item.

ECONOMY.

From the figures given under the cost of operation, it will be noted that the cost of doing plowing or other field operations with a tractor is approximately the same as with horses excepting for the item of man labor. This will average lower with the tractor than where horses are used, assuming wages to be the same in each case.

The advantage of the tractor, therefore, like that of most other improved farm machines, lies not so much in the reduction of the cost of performing a unit of work as in the fact that it permits one man to do considerably more work within a given period of time. This has been true of practically all improved farm machines, even of the grain binder, which is generally considered as one of the greatest agricultural inventions of the century, which did not, contrary, perhaps, to general opinion, decrease the cost of harvesting wheat to any considerable extent, but did increase about eightfold the acreage which one man could handle. (See Department of Agriculture Bulletin No. 627.)

Men who hope to reduce greatly the cost of farming operations by the purchase of a tractor should bear these facts in mind, and also the fact that few tractor owners mention as an advantage reduction in the cost of performing farm work. Judging by the experience of tractor users, it is not safe to expect any material reduction in the cost of farm operations per acre through the use of the tractor, but it is safe to expect to be able to increase the crop acreage to a very considerable extent, and, at the same time, the amount of crops which one man can raise.

Furthermore, it should be remembered that the cost of doing the work with a tractor as above outlined in most cases can not be

directly compared with the cost of doing it with horses, since on farms where tractors are used a number of horses generally are retained, and any comparison, therefore, must be made between the cost of operating the farm with horses alone and the cost of operating with the tractor and a certain number of horses. Not infrequently horses stand idle while the tractor is being used for field work because there is not sufficient help available to use them at the same time, and in such cases part of the cost of their maintenance must be considered when figuring the cost of farm operations, since they are as much a part of the farm power plant as is the tractor.

Neither should it be forgotten that not only should the relative expense of operation with the two methods be considered, but also the relative results. The increased crop acreage and consequent increase in incomes which the purchase of the tractor will often make possible may much more than offset a slight increase in the operating expenses of the farm.

QUALITY OF WORK.

Not a few farmers when considering the purchase of a tractor hesitate because of the fear that they may not be able to do the work as satisfactorily as with horses. This applies principally to plowing. That there is little reason for this attitude is indicated by the fact that more than 50 per cent of tractor owners report that the quality of work done by the tractor is better than that done by horses, while less than 3 per cent say it is poorer.

The quality of work done in plowing does not depend so much upon the tractor as upon the plow and its adjustment. Under average conditions, the work done by most engine gang plows when properly adjusted is fully equal, and often superior, to the work done by either a walking or gang plow drawn by horses and operated by a skillful plowman. If a job of plowing where a tractor is used is not satisfactory, it is not usually the fault of the tractor but of the plow, or, more probably, it is due to misadjustment of the plows. Of course, in fields with obstructions, sharp angles, etc., the tractor may be responsible for poor work because of its clumsiness, but under most conditions the plows and the operator determine the quality of the work done. The tractor's part is to furnish the power to pull the plows.

This point should be kept in mind by farmers who select their tractors by visiting demonstrations of different makes of outfits. The quality of the work done by different machines should be of value in selecting a good *gang plow*, but it is practically worthless in determining the value of the different tractors. It is quite possible that a tractor of very inferior quality may be pulling a good gang plow, well adjusted, and doing much better work than an outfit

of first-class quality which is pulling a poor plow or one that is out of adjustment.

The average depth of plowing done with tractors by the Illinois farmers who furnished data for this bulletin, is slightly less than 7 inches. The average depth they had previously plowed with horses was about $5\frac{1}{2}$ inches. While this deeper plowing is ordinarily considered as indicating a better quality of work, it does not appear to have had any marked effect on the crop yields.

As to the quality of disking, or other work on plowed land, it will, of course, as with plowing, depend largely upon the implement drawn and the skill of the operator. The question of packing the soil is usually more important in connection with work on plowed land than in plowing, but that this is not a serious drawback with modern tractors in Illinois is indicated by the fact that 86 per cent of Illinois tractor owners reporting say that their tractors are satisfactory for use on plowed land.

OPERATION.

In view of the fact that difficulty in operation is mentioned by tractor owners as the principal disadvantage of the tractor, it seems pertinent to state that though any man of ordinary ability can operate and care for a gas tractor very satisfactorily after a little study and experience, it is decidedly unwise for him to undertake to gain the necessary experience by experimenting with his own machine. In most cases he can obtain the experience more cheaply elsewhere. Experience in running stationary engines or automobiles, while of some value, is not enough. The mere starting of the motor, changing of gears, and stopping, are simple matters, and any farmer can quickly learn to do these, but the important thing is the ability to detect trouble the minute it begins to develop and to be able to remedy it promptly instead of allowing it to run along until an expensive delay results.

A great many owners report that it is extremely difficult to get hired help capable of operating a tractor satisfactorily. Where a tractor is to be operated by hired help it is very important for the owner to understand the proper care of the outfit in order to see that it is not abused.

The fact that a tractor does demand a certain amount of knowledge on the part of the operator can scarcely be considered a disadvantage. The necessary training usually can be obtained rather easily without great expense. It pays to spend a few days in gaining experience under a competent instructor, and it is unwise to attempt to run a tractor without such preparation. One farmer writes: "I had no experience with the tractor when I started and would have made \$500 more during the season if I had had the same

experience when I started in the spring as I had in the fall when I quit."

With the increasing use of tractors, as well as of automobiles and stationary engines, farmers are rapidly becoming familiar with the care and operation of gas engines. At the same time tractors are being improved and simplified so that difficulties in operation are growing less each year. One generation of well-trained and competent operators will disseminate information so that future generations will acquire knowledge on the subject as unconsciously, yet as thoroughly, as the average farmer's son acquires his knowledge of horses.

The mistake should not be made of assuming that any boy can operate a tractor in an efficient manner; only a proficient operator can handle a tractor properly.

Some tractor manufacturers offer to give purchasers of their machines thorough instruction at a reasonable cost. Purchasers of farm tractors should avail themselves of the opportunities thus offered to obtain a training in the use of the particular machine they will be called upon to operate, which will go far toward insuring their success in its use.

RELIABILITY.

The reliability of a tractor depends to a very great extent upon the ability of the operator. Of more than 300 tractor owners in Illinois 54 per cent reported that their outfits were not disabled a single day when needed during the past season. Of the remaining 46 per cent the average number of days their tractors were out of commission when needed was 5. This average, however, did not include one man who stated that his machine was out of commission about half the time.

The reports of tractor owners indicate that with a careful and proficient operator a gas tractor is a very dependable source of power. Occasional slight delays probably will be encountered, but serious ones will be exceptional, whereas with a careless or incompetent operator expensive delays are apt to be frequent.

Of the tractors owned by Illinois farmers reporting, about 90 per cent are operated by the owner or some member of his family, the best results usually being obtained by this class of operators. Thirty-six per cent of Illinois owners reported no time lost in the field on account of trouble with the outfit. This probably means that the time lost was not worth mentioning. Most men do not consider it trouble so long as they know at once the cause of stoppage or other irregularity in the engine's operation, and are able to remedy it promptly. The average time lost per day by the 64 per cent reporting trouble is a little over three-quarters of an hour.

DISPLACEMENT OF HORSES.

Many men expect the purchase of a tractor to enable them to do away very largely with the use of horses for farm work. Up to the present time, however, the tractor has not displaced horses to the extent commonly expected. Its greatest advantage, as before mentioned, has been in the fact that it does the heavy work quickly and thus completes it within the proper season, since it places at the farmer's command a large amount of untiring power when needed.

The tractor does displace horses to some extent, but only in about three-fourths of the cases where it is used on the same number of acres as were previously farmed. In these instances, the horses displaced average about four, and represent about three-fifths of the cost of the tractor outfit.

It should be noted that the corn belt does not offer the most favorable conditions for the displacement of horses by the tractor, since there is a great deal of work on this type of farm for which the machine can not be used profitably. The work which requires the largest amount of power on the corn-belt farm, contrary to a somewhat general opinion, is not plowing, but cultivating. In figure 1 is shown the distribution of horse labor on a typical corn-belt farm, from which it will be seen that the peak load (that is, the greatest amount of work) comes about the end of May, which is the season when corn cultivating is at its height.

Several makes of the motor-driven cultivators have recently been placed on the market. These may prove valuable auxiliaries to the tractor, particularly under corn-belt conditions. The use of these two machines on corn-belt farms probably would result in a much greater displacement of horses than where the tractor alone is used.

The raising of colts has been for years an industry of considerable importance on farms in the corn belt, and it would seem natural to expect that where tractors were bought and the work stock thus relieved of the heavy field work, the percentage of brood mares kept would be increased, and that the chances of raising more and healthier colts would be enhanced. It was found, however, that on a group of 261 farms in Illinois the brood mares constituted 27 per cent of the work stock before tractors were bought, and while the work stock decreased to some extent after the purchase of the tractor, the percentage of brood mares increased only 6 per cent, making the percentage now kept amount to 33 per cent. This is the same percentage of brood mares kept on a large group of farms in Illinois before using tractors, records of which were included in Farmers' Bulletin 719. The data contained in the bulletin mentioned showed an increase of 3 per cent in the brood mares, making 36 the percentage kept after purchasing tractors.

From these figures it does not appear that the tractor is having any very marked effect upon the percentage of brood mares in the corn belt. Certainly it is not, as a general rule, increasing the number of colts raised on farms where it is used, inasmuch as the total number of

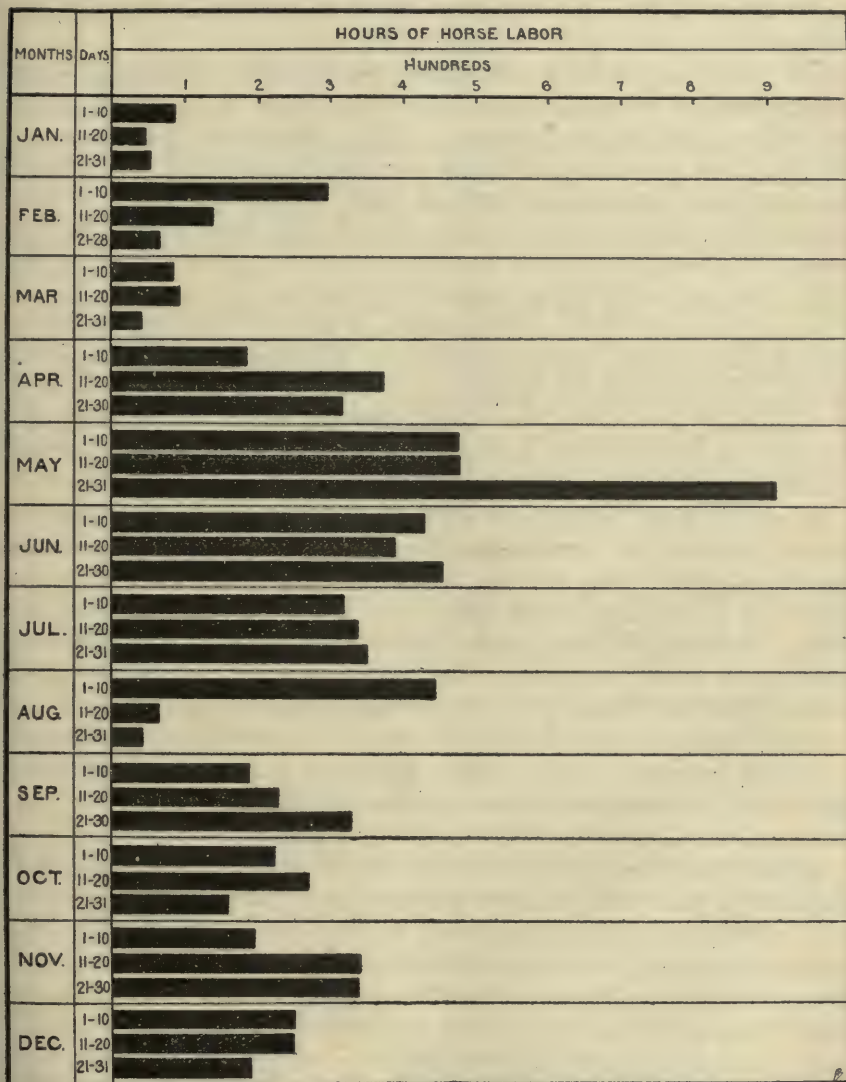


FIG. 1.—Showing distribution of horse labor on a typical corn-belt farm (in Illinois) of 200 acres, with about 120 acres of corn, 45 of oats, and 30 of hay (11 horses).

brood mares on farms where tractors were bought showed a general decrease of 8 per cent.

CUSTOM WORK.

Early in 1916 investigations showed that 45 per cent of Illinois tractor owners reporting used their outfits for custom work to some extent. A great many of them bought their outfits with the idea of

using them for such work, while others procured them for use on their own farms only, and undertook custom work at the request of neighbors or because it seemed to offer an opportunity for the tractor to help pay for itself. The investigations made in the same area in the summer of 1917 showed that this per cent had remained about constant.

The use of a tractor at custom work for field operations seems a rather reliable indication that the home farm is not large enough to utilize a tractor economically. This conclusion is borne out by the fact that the average size of the farms owned by men who use their tractors for custom work is slightly less than for the farms where the tractor is not so used. An efficient farm should be large enough to keep both labor and equipment employed during practically the entire working season. Of course, in the fall, after the work on the home farm is completed, it may be desirable to use the tractor for custom work provided an adequate return can be obtained. This, of course, means that most of the custom work will be stationary operations, such as thrashing, shredding fodder, shelling corn, etc., which can be done after the weather is unfit for field operations.

However, there seems to be some doubt as to whether it pays as a general rule to use the tractor for custom work even under these conditions. Of these Illinois tractor owners who have used their machines for custom work, one-third stated that it had not paid them. It should be noted also that comparatively few farmers consider their entire expenses when calculating the profits from this source. Most of them ignore depreciation charges, and include only fuel, oil, labor, and such repairs as may be required during the time the outfit is used. Under these conditions it not infrequently happens that a tractor owner does custom work at an actual loss, or at any rate at no real profit when all expenses are considered.

On the whole it is preferable that the machine be kept busy on the home farm during as large a percentage of the working season as practicable, so that the owner may derive the maximum profit from its use. Certainly a tractor owner is not justified in neglecting his own work to accept employment on a neighbor's farm at the rates usually paid, although this is not an uncommon occurrence. A little ready cash seems to blind some men to their own best interests and to the ultimate profit which should be made through the use of their machines at their own work. For the 47 per cent of Illinois tractor owners reporting who did custom work in 1917, the average number of days the outfit was used annually for this purpose was 17.

EFFECT OF USE OF TRACTOR ON CROP YIELDS.

The reports of Illinois tractor owners were studied to ascertain what effect the tractor has had on crop yields. The answers to the questions which were asked on this point indicate that although in-

creases are more common than decreases, they are not sufficiently frequent to warrant a farmer in attaching too much importance to this feature when considering the purchase of a tractor. The principal reasons for increases in yields were timeliness in having the work done and deeper and more thorough preparation of the seed bed in hot weather. Conservation of moisture due to the rapidity with which the work could be performed and the carrying on of more than one operation at a time were also mentioned. Decreases were usually credited to the packing of the soil when damp, and occasionally to delay in getting work done because of trouble with the outfit. By far the largest percentage of owners, however, report no noticeable effect in either direction which can be attributed to the tractor.

Although the depth of plowing done with the tractor averages about $1\frac{1}{2}$ inches greater than that done with horses, this seems to have had a rather negligible effect on yields. This is perhaps somewhat contrary to what is generally expected, but is doubtless accounted for by the fact that deep plowing alone does not necessarily increase the yields, other good farming methods and practices being required in connection therewith in order to make it profitable.

TRACTOR EQUIPMENT.

During the past few years, the farm tractor has developed more rapidly than has the field equipment for use with it, with the exception of gang plows. On many farms where tractors are used no special equipment other than plows is bought, other operations for which the tractor is used being performed with the ordinary machines designed for use with horses.

It is obviously impossible to obtain maximum results with a tractor when it is used with implements designed primarily for use with horses, and the objection of many tractor owners that the tractor can not be used with profit for certain types of field work will probably cease to hold good with the development of special machinery for use with the tractor. There is considerable activity at present in the line of inventions of implements and attachments designed especially for use with the tractor. Many of these will doubtless increase its value for farm work, making it practicable and economical for many field operations where its use is now both impracticable and uneconomical. It is for the purpose of doing work of the nature last mentioned that several horses are often kept after the purchase of the tractor. With the development of special machinery as above outlined, it seems probable that a higher percentage of work stock will be displaced where the tractor is used.

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FARM HOUSEHOLD ACCOUNTS

W. C. FUNK

Scientific Assistant



FARMERS' BULLETIN 964

UNITED STATES DEPARTMENT OF AGRICULTURE

OFFICE OF THE SECRETARY

Contribution from the Office of Farm Management

W. J. SPILLMAN, Chief

Washington, D. C.

June, 1918

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FARM HOUSEHOLD ACCOUNTS are valuable, both as supplements to the records of the farm business in general and as a means of effecting savings in operating the household. The methods of household account keeping outlined in the following pages are of the simplest character, and are intended to suggest how household accounts may be kept, rather than to outline any hard and fast system for all families to follow.

FARM HOUSEHOLD ACCOUNTS.

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IMPORTANCE OF HOUSEHOLD ACCOUNTS.

HOUSEHOLD EXPENSES on the farm are very intimately associated with the business of the farm itself. The farm normally supplies much material which otherwise would become a household expense. The household, in turn, very often furnishes board for farm labor, which would otherwise be a farm expense. Merely from the standpoint of keeping track of household expenses as related to the farm business, household accounts are desirable and should serve to supplement and round out farm accounts.¹

But the value of household accounts goes beyond this. Such accounts are an important aid to economy. A dollar saved is a dollar made, and the first step toward the saving usually lies in finding out where unnecessary expenses are incurred. This can be determined only by keeping careful records of expenses for the whole year.

Generations ago neither the farm nor the farm household had any but minor dealings with the outside world. Under such conditions the need for accounts was slight. But those conditions no longer exist. The farm household, though still in many cases receiving its major support in farm products consumed at home, purchases far more extensively than ever before from outside sources. Farm household accounts have become essential to economy.

METHODS OF KEEPING RECORDS.

There are two methods of keeping a record of household expenditures. One is to record the purchases or money paid out, without classifying the expenditures. The other is to classify when the record is made.

The first method is very simple, requires no special form, and gives all necessary information regarding expenditures (fig. 1). At the end of the month or at the end of the year the total expenditures readily may be determined. In order, however, to know the totals for each kind or class it will be necessary to make up a monthly summary (fig. 2), in which the items will be distributed in different columns, by classes. This extra work at the end of each month (or at the end of the year) may cause discouragement and neglect of

¹ Farmers' Bulletin 511, Farm Bookkeeping.

Household Expenditures.

Date 1918	Item	Value
	Amount and Kind	
Apr. 2	2# Coffee	.50
2	Shoes, ma.	4.50
2	Lamp chimney	.15
2	Flower seed	1.00
5	24# flour	1.70
5	1 doz. lemons	.30
5	2# cheese	.60
5	US Savings certificate	4.15
7	Church	.50
8	Notary fee	.25
8	Subscription 1 paper	1.00
8	Telephone bill	2.20
8	Hair cut, fa	.25
9	Emma washing	.60
10	Tea kettle	1.50
13	movie parma	.20
	Hitching	.10
	Candy and cigar	.15
	Carroll Henry	1.25
14	Missions	1.00
16	Pencil	.05
	1 bal. broom	.13
	Life insurance	25.00
	5# sugar	.45
17	ma. trip to Aunt Susie	3.20
	Catarh treatment	1.00
	Witch repaired	1.25
	Dinner in town	.40
20	Daily paper, Apr. & May	.50
	5# oatmeal	.35
	2# prunes	.20
	2 spools white thread	.10
	Total	54.53

FIG. 1.—Simple account; no classifications. When this form is used, a monthly summary arranged to show the totals of the different classes of expenditures, is essential to show the way to economy.

classification, with the result that the greatest good that could be derived from the records is not realized.

Under the second method, in addition to being entered all together in one column, the items are classified in separate columns (fig. 3). This method has the same advantages as the first method and the additional advantage of allowing for the distribution of the items of expenditure to the proper classes without the inconvenience of turning to some other page. The distribution may be left to moments of leisure if the farmer is busy at the time the entry is made. When the page is filled the next page is begun, the top line next to the heading being reserved for the total carried forward from preceding page. The items may be totaled at the end of the month and these totals carried to the summary page at the end of the book (fig. 2).

A modification of the second method (fig. 4), which classifies directly, without using a column in which all the items are included, is suggested to allow for saving space. It will be seen that with this method each item occupies but a fraction of a line. This system will thus require fewer pages than the foregoing and make it convenient to have one page to each month, thus permitting a study of the daily figures and part of the summary before the year is ended. The chief dis-

[illegible]

FIG. 2.—Form for monthly summary. This summary is used with either the simple form of accounts shown in figure 1 or the classified forms shown in figures 3 and 4.

Household Expenditures

Date	Item	Amount and Kind	Value	Animal Food	Fruits and Vegetables	General Products	Other	Clothing	Household Furnishing Expenses	Pharmaceuticals	Savings	Incidentals
Apr. 2, 1918	2 nd Coffee		.50		.87		.50	4.50				
2	Slice, ma.		4.50						.15			
2	Samp. Champaign		.15									
2	Flour seed		1.00									1.00
5	24 th flour		1.70			1.70						
5	1 doz. lemon		.30		.30							
5	2 nd cheese		.60	.60								
5	US Savings certificate		4.15								4.15	
7	Church		.50							.50		
8	Notary fee		.25									.25
8	Subscriptions 1 paper		1.00							1.00		
8	Telephone bill		2.20						2.20			
8	Hair cut, fa.		.25									.25
9	Emma washing		.60						.60			
10	Tea bottle		1.50						1.50			
13	Movie for ma		.20							.20		
	Hoteling		.10									.10
	Candy and cigar		.15									.15
	Over the Henry		1.25					1.25				
14	Mission		1.00							1.00		
16	Travel		.05							.05		
	1 bal. income		.13						.13			
	Life insurance		25.00								25.00	
			45				45					

FIG. 3.—Form of classified account. This form necessitates entering each amount twice, but simplifies greatly the work of making the monthly summary.

Household Expenditures

[illegible]

Fig. 4.—A compact form for classified account. This form economizes space, but prevents complete description and the assembling of all items in a single column.

advantage of this system is that the spaces for description of the articles bought are narrow, if the book is of the usual width, making complete description impossible.

KIND OF ACCOUNT BOOK TO USE.

The kind of book to use is not important. An ordinary blank day-book or ledger book with a stiff cover may be bought at a reasonable price. If the vertical rulings in the book do not serve the purpose others may be inserted with a pen or pencil. The blank book used by the writer has a stiff, pressed paper cover; is 12 inches long and 7 inches wide, has 34 spaces for items, contains 48 pages, and was bought at a retail store for less than 25 cents. With the vertical ruling and headings inserted, as indicated in figures 2 and 3, it served the purpose admirably. In order to eliminate the necessity of writing the headings on each page the tops of a number of pages may be cut off, allowing one set of headings to serve for all pages.

Accounts are sometimes kept in a book having small pages. A small page, however, is soon filled, is often crowded, and the information is scattered over too many pages for convenience in recording and studying the expenditures.

GROUPING OF EXPENDITURES.

Reference has been made to groups or classes of expenditures. These are suggested in order to simplify the accounts. If the farmer attempted to list the purchases of all individual items in separate columns, it would require a great amount of detail work. If, however, he groups, for instance, his expenditures for meats, lard, oysters, eggs, butter, milk, cream, and cheese under "animal food," he will have the total expenditures for a distinct class of foods. At the end of the year he may be interested to know how much cheese was bought during the year. He need then only run down the column of animal food purchases and pick out the items for cheese.

The outline which follows may be used in grouping the expenditures. The first three food groups are distinctly farm products. The totals for these groups at the end of the year will show how much was bought of these classes of food. The data thus obtained should offer suggestions as to how the expenses for goods of this class may be reduced by greater home production. On the average farm 80 per cent of the animal products and 70 per cent of the fruits and vegetables consumed by the family are taken from the farm.¹

The distribution of the different household expenditures into groups is largely a matter of individual viewpoints. The following ten divisions are suggested for the average farm family, as the smallest number of headings consistent with intelligent study:

¹ U. S. Department of Agriculture Farmers' Bulletin 635. What the Farm Contributes Directly to the Farmer's Living.

Animal food.

Meats.
Lard.
Oysters.
Fish.
Eggs.
Butter.
Milk.
Cream.
Cheese.

Fruits and vegetables.

Fresh fruits.
Dried fruits.
Canned fruits.
Citrus fruits.
Fresh vegetables.
Dried vegetables.
Canned vegetables.

Cereal products.

Wheat flour.
Rye flour.
Buckwheat flour.
Corn meal.
Hominy.
Breakfast foods.
Rice.
Bread.
Pastry.
Macaroni.
Crackers.

Other groceries.

Coffee.
Tea.
Cocoa.
Sugar.
Sirup.
Baking powder and soda.
Gelatin.
Spices.
Flavorings.
Olive and other oils.
Honey.
Nuts.
Pickles.
Olives.

Clothing.

Suits.
Shoes.
Hats.
Other clothing.
Repairs, cleaning, pressing.

Household furnishings.

Furniture.
Table and bed linen.
Curtains.
Carpets, rugs.
Kitchen utensils.

Running expenses.

Fuel.
Light.
Ice.
House servants.
Stationery and postage.
Telephone.
Laundry.
Soap.
Toilet articles.
Poll tax.
Accident insurance.
Fire insurance (contents of house).
Life insurance.

*Advancement.**Recreation:*

Picnics.
Trips.
Fairs.
Movies.

Education:

Schooling for children.
Books.
Periodicals.
Daily papers.
Music.
Pictures.
Lectures.
Chautauqua.

Benevolence:

Gifts.
Church.
Red Cross.
Charity.

Incidentals.

Doctor.
Medicine.
Dentist.
Lawyer.
Liquors.
Tobacco.
Candy.
Flower seeds.
Barber.

Savings.

Investments.
Savings-bank account.

ALLOWANCE FOR SUPPLIES PROVIDED BY HOME FARM.

It has been found that, in general, over 60 per cent of the food and over 50 per cent of the fuel consumed by farm families is produced on the farm. This important contribution of the farm is often not fully appreciated by the family enjoying it. A record of the actual products retained on the farm for family use may be of interest and value. This earning of the farm is probably of value secondary to the net cash income from crop and live-stock sales, but it is of sufficient importance on the average farm to be borne in mind in the management of the farm.

It may seem difficult to make record of each bunch of beets, each head of lettuce, each quart of berries, and each quart of milk as taken from the garden or saved from the day's supply of milk. The task is not as arduous as it may seem, however. During the summer, when the farmer's wife is very busy, she may not have time to do this every day, or she may forget. This need not seriously affect the value of the record, since the average housekeeper can estimate very closely the quantity of the different kinds of vegetables, the number of eggs, the quarts of milk, etc., used during the week. Thus she can find time once a week or oftener and bring her record up to date. At the end of the year her record probably would be sufficiently accurate for all practical purposes.

It may be well to lay special stress on the more important items. According to an investigation made by the United States Department of Agriculture with a large number of farm families, animal products which group includes meat products, poultry products, and dairy products, constitute about 75 per cent of the food furnished by the farm. All fruits constitute about 6 per cent, and vegetables about 18 per cent. Thus the garden vegetables, which are gathered in varying amounts nearly every day during the growing season, are only one-fourth as important in the aggregate as animal products.

The number of bushels or barrels of potatoes put into the cellar for winter use should be recorded and if in the spring any of these are taken out for seed or sale the quantity taken should be deducted. Do the same with beef, pork, lima beans, vegetables or fruits, or any other product saved for home use.

At the end of the year or season total the quantity of each item. To determine the value of products use the price that they would have sold for on the farm.

In keeping these records the form suggested is illustrated by figures 5 and 6. It will be noticed that the edge of the middle leaf is cut off. There are usually too many items to be listed on two pages of the open book. The short leaf will thus serve as an insert, allowing space for additional columns and at the same time making them easily available for entry.



GROWING GRAIN SORGHUMS IN THE SAN ANTONIO DISTRICT OF TEXAS

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FARMERS' BULLETIN 965
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C.

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Division of Publications, United States Department of Agriculture

A SHORTAGE of grain feed is of common occurrence on the farms in the San Antonio district of Texas. This results from planting an insufficient acreage of grain crops and from the fact that farmers rely too much upon Indian corn for grain production. Corn produces a relatively small yield per acre under the conditions existing in this district, and a complete failure of the crop often occurs. A grain crop that is more dependable than corn is urgently needed.

Experiments at the San Antonio Field Station during the past eight years indicate the possibility of making grain sorghum a successful crop in that district. Grain sorghum is a much surer crop in unfavorable years than corn, and it yields fully as much feed in favorable years. The principal reason why grain sorghum has not been more extensively planted in this district is its frequent failure to produce grain, due to blasting, or sterility. This blasting is caused by a small gnatlike fly, the sorghum midge. The results of the observations and experiments at San Antonio show that by using early varieties and special cultural methods sorghum can be made a dependable grain crop in spite of the midge.

The points of special significance to be observed are early seeding and the use of quick-maturing varieties.

GROWING GRAIN SORGHUMS IN THE SAN ANTONIO DISTRICT OF TEXAS.

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THE NEED FOR A DEPENDABLE GRAIN FEED CROP.

THE SAN ANTONIO region of Texas often experiences a shortage of grain feed on farms. This is a result of planting an insufficient acreage to grain crops and of placing too great dependence upon Indian corn for grain production. Corn makes a small yield per acre under ordinary conditions in this district, and a complete failure of the crop is not infrequent. There is urgent need for a more dependable grain crop than corn.

ADAPTABILITY OF VARIOUS GRAIN CROPS.

In an attempt to determine the adaptability of various grain crops to the local conditions, the San Antonio Experiment Farm has tested many grains, including a large number of varieties of corn, oats, and grain sorghums. These varieties were all grown without irrigation, and the results are applicable to farming conditions generally in that district. A comparison of the yields of corn, oats, and Dwarf milo (the most satisfactory grain-sorghum variety so far tested) is given in Table I, which shows the average yields of corn, oats, and Dwarf milo in the rotation experiments for a seven-year period.

TABLE I.—Average yields of oats, corn, and Dwarf milo in the rotation experiments at the San Antonio Experiment Farm, 1911 to 1917, inclusive.

Year.	Yield per acre (bushels).			Year.	Yield per acre (bushels)		
	Oats.	Corn.	Milo.		Oats.	Corn.	Milo.
1911.....	8.5	10.6	32.0	1916.....	4.5	8.5	8.0
1912.....	26.8	34.1	40.0	1917.....	6.6	10.7	19.3
1913.....	11.7	34.9	47.7	Average for 7 years (1911 to 1917).....	13.3	26.0	30.4
1914.....	15.7	52.6	43.2				
1915.....	19.5	30.3	22.8				

It is seen that with the exception of three seasons, 1913, 1915, and 1916, Dwarf milo has outyielded corn very noticeably and has outyielded oats even more. The average yield per acre of oats for seven years, 1911 to 1917, inclusive, was 13.3 bushels; of corn, 26 bushels; and of milo, 30.4 bushels. Stated in other terms, milo has yielded 16 per cent more grain than corn and 300 per cent more grain than oats. These percentages are calculated on the basis of pounds of thrashed or shelled grain. The years in which the yields of corn exceeded the yields of milo were those which were extremely favorable to the corn crop or in which poor stands and the late planting of milo resulted in excessive injury to the milo by the sorghum midge. It is in relatively unfavorable seasons that milo shows a marked superiority over corn, and these are the seasons when a shortage of grain feed on farms is most likely to occur. It is the sureness of production of the grain sorghums when seeded sufficiently early which adapts them to the irregular and uncertain seasonal conditions of the San Antonio district. The results obtained at the experiment farm and by farmers who have grown the crop appear to show that grain sorghum can be made a very satisfactory grain crop when the best varieties are used and proper cultural methods are followed.

COMPARISON OF THE HABITS OF CORN AND GRAIN SORGHUM.

Corn is not a safe crop under San Antonio conditions, mainly because of its exacting water requirements. The crop requires for its best development a very large supply of soil moisture during a very short period of its growth. If a generous moisture supply is not available at this critical time, failure to mature a full crop of grain results. Corn has very little ability to adjust its growth to conditions and wait for rain. Grain sorghum, on the other hand, has this ability. During a severe drought, the plants sometimes appear to be practically dead, but they commonly are revived by rain and make a good crop of grain. Under the same circumstances corn never recovers, no matter how favorable subsequent growing conditions may be.

CONDITIONS AFFECTING GRAIN-SORGHUM PRODUCTION IN THE SAN ANTONIO DISTRICT.

One of the principal reasons why grain sorghum has not been planted more extensively in the San Antonio district is its frequent failure to produce grain, due to blasting, or sterility. The cause of this difficulty was discovered at the Louisiana Agricultural Experiment Station, Baton Rouge, and at the San Antonio Experiment Farm several years ago to be a small gnatlike fly, the sorghum midge.¹ This fact, however, is not yet so widely known by farmers

¹ Ball, C. R. The sorghum midge. *In Science*, n. s., v. 27, no. 681, p. 114-115. 1908. Ball, C. R., and Hastings, S. H. Grain-sorghum production in the San Antonio region of Texas. U. S. Dept. Agr., Bur. Plant Indus. Bul. 237, 30 p., 4 fig. 1912.

as it should be, many still holding the old view that blasting is caused by rain at flowering time. The sorghum midge is very generally distributed throughout the San Antonio district, and there is practically never a season when the insect is not present for some time. If any of the sorghum crops are in the right condition when the midge appears, the insect will damage the crop in varying degrees, ranging from slight injury to complete prevention of grain production.

THE SORGHUM MIDGE.¹

The sorghum midge is a very small gnatlike fly, which passes the winter season in the cocooned larva stage. These larvæ are found in Johnson grass and sorghum heads which are left in fence corners, along roadsides, and in other places. On the approach of warm weather in the spring and when Johnson grass or sorghum begins heading, the larvæ change to pupæ, then to adults, which begin immediately a search for a place to deposit eggs. During the winter season a large proportion of the insects die from various causes, so that at the opening of spring only a comparatively small number of larvæ remain alive. As soon as any of the sorghum crops or the Johnson grass reaches the flowering stage, the female insects begin depositing eggs in the flowers. These eggs are deposited inside the inner glume adjacent to the ovary. They hatch into a pink or white grub, which lies next to the ovary or developing grain and absorbs the plant juices. The ovary shrinks and fails to develop normally and a sterile spikelet results. When the larva becomes fully developed, it changes to the pupa stage and finally emerges as an adult midge. Immediately after this emergence, copulation takes place, and the female midge begins a search for a place to deposit her eggs. She continues to deposit eggs throughout her short life and when the egg supply is exhausted dies. The life cycle is repeated, and this continues so long as the weather conditions are favorable and there is sorghum heading to furnish a place for depositing eggs. The life cycle, i. e., the time required for the adult to develop from a newly deposited egg, varies according to weather conditions from 14 days upward, the most rapid development occurring during the warmest weather.

The first midges appear when the Johnson grass or sorghum begins heading, and the insects continue to increase in numbers until their food supply is greatly reduced or exhausted. They are, therefore, found in greatest abundance sometime after the sorghum crops begin heading. They usually are present in varying numbers throughout the remainder of the season or until frost kills the host

¹ For a full discussion of the life history and habits of the insect, see Dean, W. H., The sorghum midge. In U. S. Dept. Agr., Bur. Ent. Bul. 85, p. 39-58, fig. 20-31, 2 pl. 1910.

plants. Due to the irregularity in their food supply, the insects appear in great numbers at irregular intervals throughout the summer, depending upon seasonal conditions. For that reason there are frequently periods during the summer when only slight injury is done to the sorghum crops by the midge. There is no way of knowing, however, when these periods will occur. On that account, sorghum that is flowering during the summer is in constant danger of a severe infestation, which will result in the complete failure of the seed crop.

EVADING THE SORGHUM MIDGE.

As there is no satisfactory way of combating the sorghum midge by treatment and as all sorghum varieties appear to be susceptible to its attacks, the only known method of dealing with the insect is to evade it. Fortunately, its life habits are such as to make evasion possible. If the sorghum plants flower at times when the midges are least numerous and consequently unable to do serious damage, a satisfactory seed crop may be produced. Observations upon the behavior of the sorghums in the San Antonio district revealed the fact that when quick-maturing varieties were seeded early and consequently matured early, the sorghum midge failed to damage the grain crop seriously. This led to the use of early varieties and the practice of early seeding at the San Antonio field station. Since the adoption of these precautions, a complete failure of the crop has not been experienced.

CULTURE OF GRAIN SORGHUMS.

It appears from the foregoing that a means of overcoming the most serious obstacle to grain-sorghum production in the San Antonio district has been found. It is believed that the best and surest means of increasing grain production in the region is more extensive planting of this crop. It is desirable, therefore, to discuss the best varieties for the district and to outline briefly the necessary cultural methods to employ in the production of the crop.

BEST VARIETIES FOR THE DISTRICT.

The testing of grain-sorghum varieties has been conducted at the San Antonio field station since 1909. All varieties in commercial production in the United States and a great many which have never been grown generally by farmers have been tried. The great importance of early maturity has already been emphasized. Early maturity is secured best by the early seeding of a quick-maturing variety. The results of experiments at the San Antonio field station show that Dwarf milo (fig. 1) and feterita (fig. 2) are the best varieties for

grain production in that district. The grain yields of Dwarf milo have averaged approximately 25 per cent more than those of feterita. Both varieties require practically the same time for maturity. Dwarf milo does not grow so tall as feterita and is usually more uniform in growth and height; hence, it is less difficult to harvest and thrash. It is also apparently less susceptible to bird damage, probably on account of the softness and lack of tannin of the feterita grain. Neither does it shatter nearly so rapidly in the field, and consequently it suffers less from delayed harvesting. The advantages of Dwarf milo over feterita appear sufficiently great to recommend it unconditionally wherever the principal object is grain production.



P4663WI

FIG. 1.—A plat of Dwarf milo at the San Antonio Experiment Farm. This variety has given the best results of all the grain sorghums tested at this place.

On account of its taller growing habit, feterita may produce a slightly larger quantity of roughage than milo. However, the larger quantity of grain in milo fodder would probably increase its feeding value to such a degree as to make it superior to feterita, even for fodder or silage. The stalks of both milo and feterita are rather woody and dry and are inferior in palatability and feeding value to kafir, but on account of the lateness of maturity of the kafirs and consequently their greater susceptibility to sorghum-midge damage, they usually produce less grain than either Dwarf milo or feterita. It is believed that when it is possible and desirable to plant grain sorghum from July 1 to 15, kafir is the most desirable variety for such planting. Under these conditions of planting, the crop would reach maturity late enough in the fall to escape serious sorghum-midge damage, and it might even yield a greater amount of grain than milo or feterita. In case of subsequent drought, other unfavor-

able growing conditions, or frost before maturity, the forage of kafir would be more valuable and probably in larger quantity than that of either milo or feterita. The best variety for such planting is that known as Early or Sunrise kafir. This is as early as Dawn or Dwarf kafir, produces a larger stalk and a greater total yield of fodder, and is about equal in grain production.

In order to make possible early seeding, which has been emphasized as of greatest importance, the early and thorough preparation of the seed bed is necessary. The seeds of sorghum are rela-



FIG. 2.—A plat of feterita at the San Antonio Experiment Farm. While this variety of grain sorghum has not yielded quite as well as Dwarf milo, it has proved to be well adapted to conditions in the San Antonio district.

PREPARATION OF THE LAND.

tively small and must not be planted too deep or in cold ground, on account of danger of decay and a consequent poor stand. The seed bed should be smooth, firm, and moist, in order that the seed may be planted in moist soil and covered to a uniform depth. This is necessary so that rapid and uniform germination may take place and a good stand secured. Strong, vigorous, rapid-growing plants will result, which will develop earlier and more uniformly than if planted on a poorly prepared seed bed.

If possible, the land on which grain sorghum is to be planted should be plowed early the preceding fall, as this will facilitate the storing in the soil of moisture from the fall and winter rains. The land should be harrowed several times during the winter, particularly after rains, to maintain a soil mulch and to keep the soil granular, so that it may readily absorb the subsequent rainfall. Such har-

rowing will break the clods, smooth and firm the soil, and develop a good seed bed.

TIME OF SEEDING.

Observations and experiments at the San Antonio field station indicate that seeding should be done from March 5 to 20, and never later than April 1 if the best results are to be secured. In occasional years, late spring frosts may injure or even kill the seedlings when planting is done very early, making replanting necessary, but the advantage in early seeding will more than offset the risk of such damage. Aside from the danger of frost injury, extremely early seeding, as in February, has been found to be undesirable, as the sorghum seeds decay quickly under unfavorable conditions and poor and nonuniform stands result. Moreover, the growth of the plants is often delayed by cold weather, and later seedings have been observed to reach maturity practically as soon as the crops resulting from extremely early seeding. As such a small quantity of seed is required it is recommended that seeding be done as soon as weather conditions permit after March 5 and if a poor stand is obtained that reseedling be done not later than April 1. These recommendations apply particularly where Dwarf milo or feterita is the variety grown. In addition to evading the injury of the midge, early seeding will enable the crop to reach maturity before the hot, dry weather of summer.

In occasional years, as in 1917, sorghum seeded later than April 1 may not be materially injured by the sorghum midge. Therefore, when early seeding is impossible on account of seasonal conditions, later seeding may be done. It should always be borne in mind, however, that complete failure of the grain is likely to occur. In such a case, the crop may be utilized for roughage. Observations and preliminary experiments indicate that when sorghums reach maturity very late in the season, the chances for the development of the seed are much better than when they mature during midsummer. Therefore, it is recommended that early seeding, before April 1, be employed whenever possible, and late seeding, that is, in late July, so that the late crop will begin blooming about October 1, be practiced when it is desired to grow grain sorghum for a fall crop.

METHOD OF SEEDING.

The grain sorghums may be seeded with an ordinary 1-row or 2-row combined corn and cotton planter equipped with the small-hole plates usually furnished with such planters. The number and sizes of holes to use in these plates will depend upon the size of the seed and the thickness with which it is desirable to seed. This will de-

pend upon the variety used, the seed of kafir being much smaller than milo or feterita seed. It is also sometimes necessary to seed feterita somewhat more thickly than milo, since the seed is often of low vitality. If hand thinning is to be done, thick seeding can be practiced. This will insure a better and more uniform stand, but the expense and objections to hand thinning must be taken into consid-



P2632W1

FIG. 3.—Close-spaced milo plants, showing almost total freedom from tillers and resulting high uniformity, at the San Antonio Experiment Farm.

eration. When early seeding is practiced seed should be distributed somewhat more thickly than it is desired to have the plants, inasmuch as some seed will fail to germinate. It is, of course, desirable to test the seed for germination, and in case the vitality of the seed is low the rate of seeding should be increased sufficiently to insure a good stand. The rate of seeding should be about 6 pounds per acre for milo, 6 to 8 pounds for feterita, and about 4 pounds for kafir.

Experiments indicate that the grain sorghums should be seeded in rows $3\frac{1}{2}$ to 4 feet apart. The most desirable distance between the plants within the row depends somewhat upon the variety used, milo and feterita requiring somewhat closer spacing than kafir. The results of a series of experiments made at the San Antonio field station in 1913 and 1914 indicate that with Dwarf milo somewhat thicker seeding is desirable in that district than has ordinarily been advocated for other sections.¹ These experiments indicate that Dwarf milo plants should be from 3 to 4 inches apart in rows 4 feet apart. This relatively close spacing (fig. 3) resulted in less tillering, fewer pendent heads, more uniform and earlier maturity, and larger yields of grain.

The seed should be planted in moist soil and covered uniformly not more than $1\frac{1}{2}$ inches deep. In order to make this possible when the surface soil may be dry and uneven, some sort of furrow opener to throw back the dry surface layer has been found advantageous. This has been accomplished at San Antonio by bolting a short piece of 2 by 4 timber to each side of the planter shoe. This arrangement has worked very satisfactorily and has made possible seeding under conditions of soil moisture which would not otherwise have been advisable. Seeding in shallow lister furrows may also be practiced.

CULTIVATION.

The crop may be cultivated in the same way and with the same implements as the corn crop. Cultivation should be started while the plants are small, in order to prevent the growth of weeds. It should be shallow, not more than about 3 inches deep. The operation may be repeated until the plants are too large to allow the cultivator to pass between the rows readily.

HARVESTING AND THRASHING.

The method of harvesting to be employed will depend upon the use to be made of the crop. The heads may be removed by cutting with a knife from the stalks standing in the field or the entire plant may be cut with a row binder, as shown in figure 4, or by hand. In either case, several days of curing are necessary before thrashing can be done. With varieties having a small proportion of stalk, such as Dwarf milo, the entire stalk can be put through the thrasher, or the heads may be removed with a cutter of some kind and they alone put through the thrasher. The heads may also be fed to live stock without thrashing, in much the same way as ear corn, although better results, except for sheep and poultry, are usually obtained

¹Hastings, S. H. The importance of thick seeding in the production of milo in the San Antonio region: U. S. Dept. Agr. Bul. 188, 21 p., 9 fig. 1915.

when the sorghum grains are ground before feeding.¹ With certain kinds of grinders it is possible to grind the unthrashed heads, making what is commonly known as head chops. Thrashing is done with an ordinary grain separator, although, on account of the danger of cracking, it is desirable to reduce the speed of the cylinder to about 600 or 800 revolutions per minute and to remove some of the concave teeth. Reducing the speed of the cylinder is particularly necessary where the heads alone are put through the separator.



FIG. 4.—Harvesting Dwarf milo with a row binder at the San Antonio Experiment Farm.

USE OF SORGHUM GRAIN.

Speaking generally, sorghum grain may be used for the same feeding purposes as Indian corn. All live stock relish it and make rapid and satisfactory gains when it is fed to them. The grain has also long been highly prized for poultry feeding. It may also be ground into meal and used for human food in the same way as corn meal, and the meal may be used as a substitute for a portion of the wheat flour in yeast bread.

¹ Scott, G. A. The feeding of grain sorghums to live stock. U. S. Dept. Agr. Farmers' Bul. 724, 14 p., 5 fig. 1916.

A SIMPLE HOG-BREEDING CRATE

J. H. ZELLER

Animal Husbandry Division



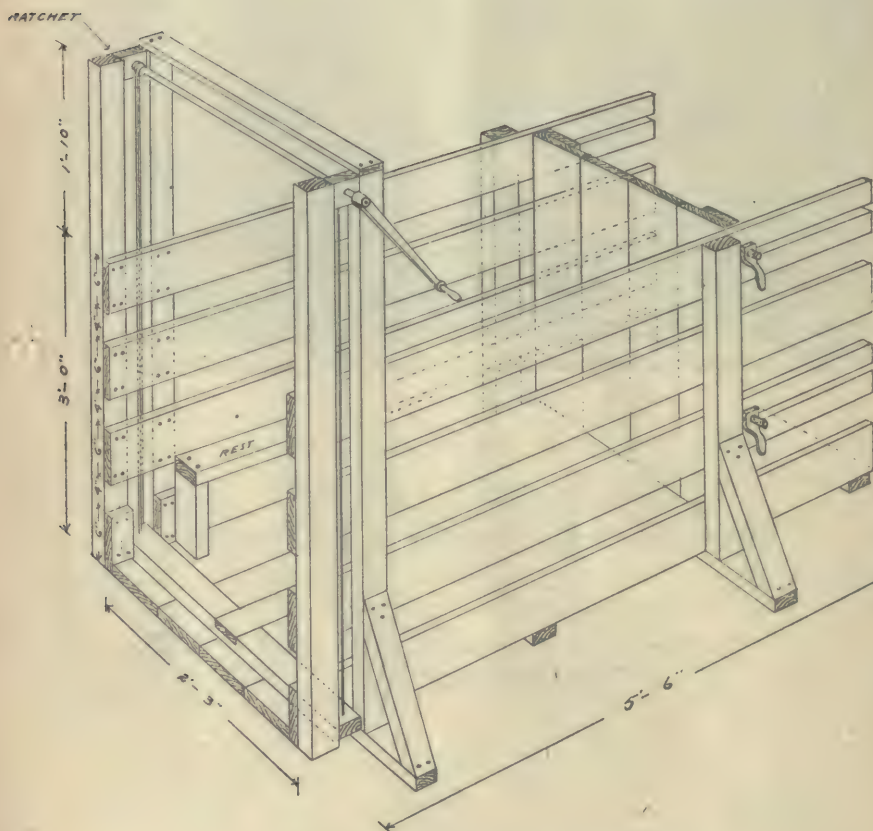
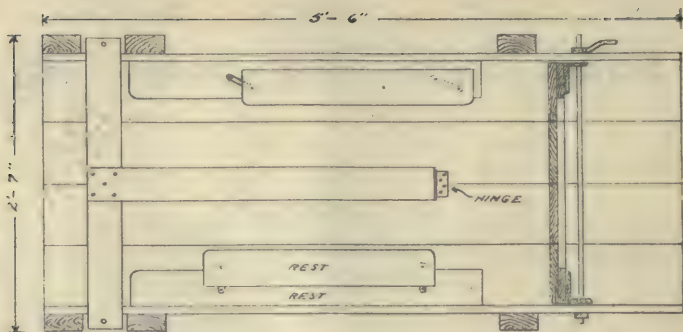
FARMERS' BULLETIN 966
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief

WASHINGTON, D. C.

APRIL 22, 1918

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Plan for hog-breeding crate. Floor plan above.

ADVANTAGES OF THE BREEDING CRATE.

PROPER MANAGEMENT at breeding time frequently results in the breeding of a great many sows that otherwise might fail to mate and would necessarily have to be carried over to the next season, thus involving expense without producing a litter of pigs. This condition may be partly overcome by the use of the breeding crate, which is growing in popularity.

Some sows when in heat will not take the boar readily and will often hinder a successful service by lowering the vitality of the male. When a small sow is bred to a large, heavy boar there is danger of injury to the sow if some mechanical device is not used to help bear the weight of the boar. Such a device can also be used to advantage when a small boar is mated to a large sow.

There are many types of breeding crates which the farmer may construct. The accompanying illustrations show a crate that can be operated by one man and is easily constructed on the average farm without involving much expense.

DIRECTIONS FOR OPERATION.

The sow is driven into the open end of the crate until her hind feet are in front of the crosspiece of the T-shaped lift. The sow is elevated by means of the lift, which is drawn up by a windlass as shown in the illustration. A ratchet on the windlass holds the sow at the desired height. The partition at the front end of the crate operates on a slide and can be arranged to suit the length of the sow. Thus, if the sow is large the partition can be moved toward the end of the crate to allow plenty of space without cramping her, and in the case of a small sow the partition is moved closer to eliminate an undue amount of space. The point to remember is that the animal should be in a natural position in order to obtain the best results.

When the sow is properly placed the boar is brought up. His hind feet should rest on a flat cleated platform laid on the ground to give him a solid footing. The cleats should be 1 by 2 inches to prevent slipping. His front feet will fall upon the rest as shown in the drawings, the sow being required to bear only a small part of his weight. The sow should then be raised or lowered, as the case may be, to the proper height by means of the windlass. When a small sow is bred the short top rests are extended to hold her firmly in position.

After breeding, the boar is driven to his pen or paddock. The sow is removed from the crate either by releasing the ratchet on the

windlass and allowing her to back out or by removing the sliding partition so that she may walk out the front end of the crate.

BILL OF MATERIALS FOR CONSTRUCTING A CRATE.

Dressed or undressed lumber may be used in the construction of a breeding crate. The material required will total about 140 board feet of lumber of the following dimensions:

5 pieces, 2 by 4 inches by 16 feet long, for uprights and sides.

14 pieces, 1 by 6 inches by 12 feet long, for sides and flooring.

HARDWARE, ETC.

2 pieces, $\frac{1}{2}$ -inch iron rods 30 inches long, with 2 wing nuts, as shown in illustration, for sliding partition.

1 piece, 1-inch pipe 2 feet 10 inches in length, with handle and ratchet, for windlass.

12 feet sash cord, for windlass.

1 pair hinges.

4 angle irons, $\frac{3}{8}$ -inch thick by $1\frac{1}{4}$ inches in width, and med. 2 by 3 inches, as shown on the sliding partition.

5 pounds 10-penny wire nails.

2 pounds 20-penny nails.

It is not absolutely necessary to construct the crate as shown. Other methods of making a windlass that will answer the desired purpose may suggest themselves. For instance, instead of being made of iron it could be made of wood in much the same manner as the old wooden windlass used over wells.

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PURPLE VETCH

ROLAND McKEE

Assistant Agrostologist, Office of Forage-Crop Investigations



Field of Purple Vetch

FARMERS' BULLETIN 967

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry

WM. A. TAYLOR, Chief

Washington, D. C.

June, 1918

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Division of Publications, United States Department of Agriculture

PURPLE VETCH is a new crop, promising to prove of special value for green manure in the southwestern United States and as a seed crop in western Oregon.

It is of high feeding value and makes good hay and pasturage.

It is similar to common and hairy vetch, but is less winter hardy than either of these.

Under average conditions it will stand a winter temperature of 15° F. above zero with little or no injury.

Where the temperatures do not fall below 15° F., it should be sown in the fall. With colder winter conditions spring seeding is essential.

Inoculation is advisable in most localities when growing the crop for the first time.

Purple vetch should be drilled in close drills or broadcasted at the rate of 60 to 80 pounds of seed per acre.

Harvesting can be done best with a common mower with a swather attachment. An ordinary thrasher can be used.

The average yield of seed is 12 to 15 bushels per acre.

PURPLE VETCH.¹

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WHERE GROWN.

PURPLE VETCH was brought into the United States by the Office of Foreign Seed and Plant Introduction in 1899 from Naples, Italy. All introductions since that time have been of the same variety. The crop has been tested most extensively in the Pacific Coast States, where it has given very favorable results. In California in experimental work it has proved one of the best crops, if not the best crop, for use as a green manure, and in commercial plantings it has been thought well of by the orchardists who have used it. In western Oregon and western Washington, experimental work has demonstrated that purple vetch can be grown successfully as a seed crop, and at the present time a limited acreage is being grown in the Willamette Valley of Oregon and the Puyallup Valley of Washington. Purple vetch has not been sufficiently tested in the Southern States to determine definitely its value in localities where common vetch is now being grown. However, as it requires conditions similar to common vetch, it seems probable that it may serve an excellent purpose in this region as well as in the western United States.

DESCRIPTION.

Purple vetch is an annual. It has much the same habit of growth as common vetch.² The length of the stems is usually from 3 to 6 feet. From seven to nine pairs of leaflets, terminated with a tendril, constitute the leaf. The leaflets are long, oval, and covered with down, giving the plant a silvery gray cast. Twenty or more

¹ *Vicia atropurpurea*.

² *Vicia sativa*.

amaranth-purple flowers are borne in numerous conspicuous clusters (fig. 1). The plump, hairy pods, from 1 to 1½ inches in length, contain from four to five seeds of a solid velvety black, with a prominent white scar at the point of attachment to the pod. (Fig. 2.)

SIMILAR SPECIES.

While there are a number of species of vetch that are more or less like purple vetch, the only one grown commercially with which it



FIG. 1.—Stem of purple vetch in flower.

might be readily confused is hairy vetch.¹ Both of these species have flowers borne in dense clusters, and the pod and vine characters are more or less similar. The flowers of hairy vetch are more of a bluish purple than those of purple vetch, which tend to a red rather than a bluish cast. Woolly-podded vetch² is quite like the purple and hairy vetches, but is readily distinguished from purple vetch by having pods with very little or no down and a finer stem growth. It is distinguished from hairy vetch by having flowers with a reddish purple cast rather than the bluish purple which is common to hairy vetch. The seed characters readily distinguish purple vetch from the hairy and woolly-podded vetches. While the seeds of the two latter species are more or less similar, that of purple vetch can be readily distinguished by the prominent white scar at the point of attachment to the pod.

CLIMATIC REQUIREMENTS.

The climatic requirements of purple vetch are similar to those of common vetch; it is, however, a little less winter hardy. In severe winters in western Oregon purple vetch has been injured more than

¹ *Vicia villosa*.

² *Vicia dasycarpa*.

the common vetch, though in no season since it has been planted in that region has it been entirely winterkilled. The winter temperatures that purple vetch will stand vary more or less with other factors, such as snow protection and the amount of moisture in the soil, but under average conditions this crop will stand a temperature of about 15° F. above zero with little or no injury. (Fig. 3.)

SOIL AND MOISTURE REQUIREMENTS.

Purple vetch does best in heavy loams or clay loams, though it has done fairly well on sandy and gravelly soils. It prefers a well-drained soil. In western Oregon in some cases it has done better on low and poorly drained land than common vetch, but in no instance has a good crop been produced under such conditions.

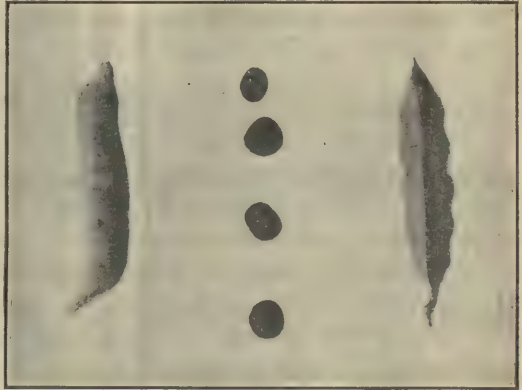


FIG. 2.—Pods and seeds of purple vetch.

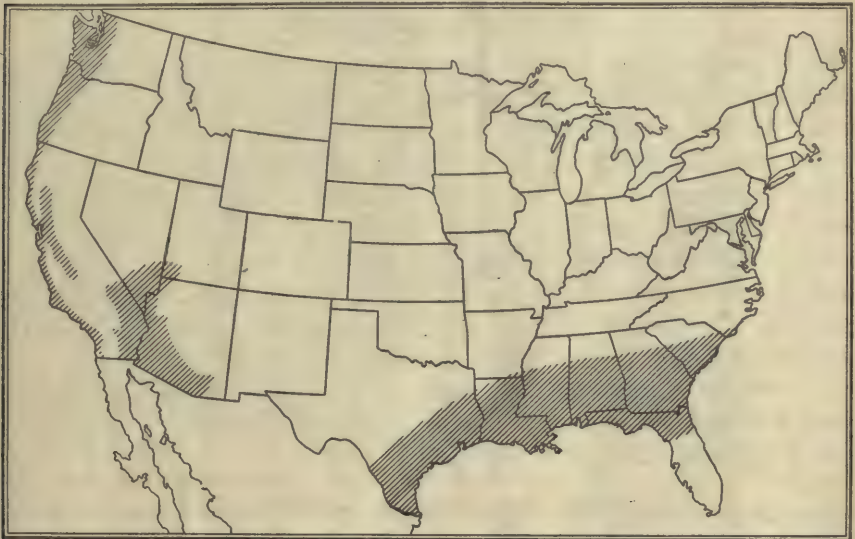


FIG. 3.—Outline map of the United States, with the shaded portions showing the areas where the climatic conditions are favorable for the fall seeding of purple vetch.

VALUE FOR HAY.

Little experimental work has been done to determine the value of purple vetch for hay. Its principal uses thus far have been as a green-manure and seed crop. In incidental feeding tests, live stock have eaten purple-vetch hay readily and seem to relish it as much as

common-vetch hay. Chemical analyses indicate its feeding value to be about the same as common vetch. On account of the heavier hairiness of purple vetch it might seem less desirable for hay than common vetch, but as it is less hairy than hairy vetch, which has been used extensively for hay and with apparently no bad results, it is not likely to give trouble in this regard.

VALUE FOR GREEN MANURE.

In comparison with the other vetches and also with various other winter annual legumes, purple vetch has proved of special value for green-manuring purposes. In orchard sections of California where green-manure crops are used quite extensively, purple vetch has given better results by reason of a heavier growth than field peas, common vetch, fenugreek, bur clover, and sour clover, all of which have been used extensively at various times in commercial plantings. The superiority of purple vetch lies in its ability to make more growth in a cool winter season and thus be ready to turn under at an earlier date in spring. This is quite an important factor in the citrus groves of the Southwestern States, where it is desirable to turn under green manures by the middle of February or not later than the first of March. Aside from the heavy early growth made by purple vetch, the total yield has been large and equaled by few other crops.

VALUE FOR PASTURAGE.

While purple vetch has no special qualities to make it superior to common or hairy vetch for pasture purposes, it is equal to either of these varieties in this respect and can be used in the same way. Purple vetch affords good pasturage for all kinds of stock, and under mild climatic conditions, where fall seeding is possible, if sown quite early it will afford good pasturage in the fall and a large quantity of pasturage the following spring. In growing vetch for a seed crop when planting is made in the fall, it is often desirable to pasture lightly in the spring, in order to prevent an excessive vine growth, which makes harvesting more difficult and often reduces the seed yield. When pasturing a seed crop in this way, sheep perhaps can be used to better advantage than any other live stock on account of their doing less damage by trampling.

TIME AND RATE OF SEEDING.

The time of seeding purple vetch will vary in different parts of the country and also with the purpose for which the crop is to be grown.

In Oregon and Washington west of the Cascade Mountains, purple vetch should be sown in February or March, or as soon as possible after the coldest weather of the winter has passed. Plantings made later in the season will give good results in seasons having a late spring, but in years in which the rainy season terminates early, late plantings are apt to give light yields.

In California west of the Sierra Nevada Mountains, in the southern part of Nevada, and in the southwestern half of Arizona, planting should be done in the fall. Purple vetch is winter hardy in all the milder parts of California and Arizona, and in practically no agricultural area of these States except in the mountain region will the crop winterkill.

When the crop in this area is grown for green manuring and with irrigation, planting should be made from the middle of August to the middle of September.

When planting for hay purposes in California without irrigation, purple vetch should be sown on fallow land in the fall, before the winter rains begin.

Purple vetch has been tested but little in the Southeastern States, and the best time for planting it has not been determined, but fall planting seems most likely to be successful.

When sown for green-manuring, seed, or hay purposes, purple vetch should be seeded at the rate of 60 to 80 pounds per acre. Under favorable conditions a smaller quantity of seed may be used, but ordinarily at least 60 pounds will be found essential. When seeding with grain for hay purposes, the mixture should contain about 40 pounds of purple-vetch seed per acre and about half the amount of grain used when seeding grain alone.

INOCULATION.

In the Pacific Coast States, where common vetch is almost always naturally inoculated, the necessary bacteria apparently being present in the soil, it is not necessary to inoculate for purple vetch. In the Atlantic Coast States and the States bordering the Gulf of Mexico inoculation is essential in most cases when land is seeded to vetch for the first time. Elsewhere in the United States it is advisable, if not essential, that the soil be inoculated in seeding for the first time. Inoculation is more difficult to secure on poor soil than in richer or more loamy soils containing a higher percentage of organic matter. In seeding land to purple vetch for the first time, inoculation can be made more certain if a heavy application of manure is made the preceding season. One method of inoculation is by scattering soil from a field where vetch has been grown with success. The soil should be broadcasted at the rate of 250 to 500 pounds to the acre and harrowed in at once. Inoculation may be also secured by mixing the soil with the seed at the time of seeding. In this way but little soil will be needed to inoculate a large area, and practically no extra time or labor is required. Where inoculated soil is not available, pure cultures may be used. The same germ produces nodules on common vetch, hairy vetch, and purple vetch, so that cultures used for the first two varieties may be used for the last.

METHOD OF SEEDING.

Purple-vetch seed may be sown either broadcast or by drilling. Drilling has the advantage of being more economical, but often a drill is not available or can not be secured conveniently, and in this case broadcasting can be done with very satisfactory results. In sections where common vetch is now used extensively, opinion differs as to the relative merits of drilling and broadcasting. It is the contention of some that broadcasting gives results equally as good as drilling, but it seems to be the belief of more experienced farmers that drilling not only saves seed, but also insures a better stand by reason of less winterkilling in severe seasons. Experimental plantings have given better results from drilled plats, and this apparently has been due to better germination and less winterkilling.

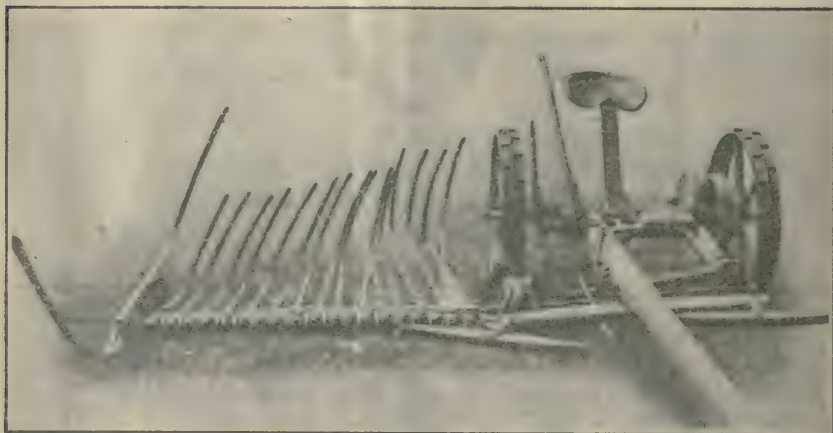


FIG. 4.—An ordinary mower with a swather attachment used in cutting vetch.

USE OF LIME AND GYPSUM.

In the Southern States and in Washington and Oregon west of the Cascade Mountains, it is the common practice to use lime and gypsum in connection with the growing of common vetch. The requirements of purple vetch with regard to lime are the same as those of common vetch. While the general practice in Oregon has given very favorable results with common vetch, experimental work at Corvallis, Oreg., showed only a slight increase of seed or hay from the use of lime or gypsum. The better drained lands of western Oregon and western Washington perhaps require little, if any, lime, but on the lower and less well drained lands lime will give very satisfactory results. Under such conditions an application of from 1 to 2 tons per acre is recommended. Gypsum can be used to advantage on practically all lands. From 100 to 200 pounds per acre should be applied.

HARVESTING FOR HAY.

Purple vetch should be cut for hay during the period from full bloom to the formation of the first pods. It can be satisfactorily cut with an ordinary mower with a swather attachment (fig. 4). After cutting, the vetch should be bunched with a horserake and then shocked. This handling should always be done before the leaves are dry. The vetch should be allowed to cure in the shocks for several days and hay caps used, if possible, in regions where rainy weather is feared. Where a swather is not used, the cutting is considerably more difficult. In either case the vetch should be allowed to lie one day before shocking. Purple vetch yields from $1\frac{1}{2}$ to $3\frac{1}{2}$ tons of hay to the acre, an average yield being about $2\frac{1}{2}$ tons.



FIG. 5.—A mower with a swather attachment in operation.

HARVESTING FOR SEED.

Purple vetch should be cut for seed soon after the lower pods are ripe, at which time the upper pods will be mature and the plant will be carrying a maximum quantity of seed. Later cutting occasions more dropping of pods, while earlier cutting results in a considerable percentage of immature seed. Purple vetch is less exacting as to the time of cutting than common vetch, as the seed shatters less readily, but when purple vetch becomes overripe the seed shatters more or less, and often the pods drop from the vine without bursting. An ordinary mower can be used in cutting purple vetch, but this is not entirely satisfactory, as much of the seed is lost in raking, which is necessary when a common mower is used. An ordinary grain binder can be used with good results, especially when the vetch is short or when it is grown with a support crop, such as oats. When

harvested in this manner the crop should be put in shocks, following the practice with grain, and allowed to remain until thrashed. The most satisfactory way of harvesting purple vetch, however, is to use an ordinary mower with a swather attachment. The swather, which is attached to and behind the sickle bar, rolls the vetch in a swath to the outside and leaves the way clear to cut the next swath. (Figs. 5 and 6.) Whatever method is used in cutting, the vetch should be put immediately into shocks and allowed to remain there until thrashed. The most important rule in the harvesting of vetch seed is to handle the crop as rapidly and as little as possible.



FIG. 6.—A crop cut with an ordinary mower with a swather attachment.

THRASHING.

Purple vetch can be thrashed with an ordinary thrashing machine (fig. 7). It thrashes slowly and consequently the expense is high. On account of its nonshattering character the seed is more difficult to remove from the pods than that of common vetch. However, this is no serious objection, experience in handling this crop indicating that it can be thrashed at practically the same expense as common vetch. Usually 20 to 25 cents a bushel is charged for thrashing common vetch, and the cost is about the same whether the vetch is thrashed by the bushel or a thrashing machine is hired by the day. When vetch and oats or other small grain are grown in mixture and cut with a binder the thrashing is usually done for 10 cents a bushel. However, this means that the additional cost of thrashing the small grain brings the price of thrashing the vetch seed up to practically the figure charged for thrashing vetch alone.

CLEANING SEED.

Purple-vetch seed is about the same size as common-vetch seed, which means that it is practically the size of wheat. The separation of purple-vetch seed from wheat or hull-less barley is therefore quite difficult, and it is only with special machinery that such separation can be accomplished. Other small grains, such as oats, rye, and common barley, can be separated from purple-vetch seed quite easily with any of the common seed-cleaning devices used for the small grains (fig. 8). The separation of most weed seeds found in the vetch sections of the United States can usually be made with the ordinary separating devices now in common use.



FIG. 7.—Thrashing vetch seed with an ordinary thrasher.

YIELD OF SEED.

Purple vetch varies considerably in the yield of seed to the acre. A yield of 5 bushels is low, and yields of 20 to 25 bushels are near the maximum. An average yield is probably from 10 to 12 bushels per acre, or about the same as common vetch. In experimental plats at Corvallis, Oreg., yields ranging from nothing to 29 bushels per acre have been secured. The cases of total failure were due to the winterkilling of fall plantings in the winter of 1914-15. In commercial plantings in western Oregon and western Washington, the yields have ranged from nothing to 20 bushels per acre, the failures being due to winterkilling.

INSECTS IN RELATION TO POLLINATION.

The pollen of the purple-vetch flower is maturing just before the flowers open. In experiments to determine whether or not cross-pollination is essential to seed setting it has been determined that

plants covered with tarlatan netting and protected from insects produce practically as good a seed crop as plants in the open, while plants in paper bags set no seed. From this, it seems that visitation by large insects is not essential, while small insects may be quite beneficial. However, many of the larger insects, such as honeybees, bumblebees, and sweat bees, visit the purple-vetch flowers. Honeybees and small bumblebees in working the flowers do not trip them or force the staminal column through the keel. The insect forces its proboscis between the calyx tube and standard and wings, but this does not effect tripping. Large bumblebees trip the flowers. The weight of their bodies is sufficient to force the staminal column through the keel, but this again returns or springs back as soon as the bumblebee leaves the flower.



FIG. 8.—Cleaning vetch seed with a power cleaner.

While there are no definite data regarding the value of purple vetch as a honey-producing plant, it would seem from the fact that vetch fields are so generally visited by honeybees that a large amount of nectar probably is produced.

INJURIOUS INSECTS.

There is only one insect that has caused any serious damage to the purple-vetch crop. This is the aphid which also does serious damage to the field pea and common vetch. In growing field peas, common vetch, and other leguminous crops in comparison with purple vetch, it has been noted that the aphid does much less injury to the purple vetch than to the other crops. This has special significance both in growing the crop for green manure and for seed. In seasons favorable to aphid development, damage has been done to the vetch-seed crop by the insects sapping the seed pods and thus preventing their development; also, in growing the crop for hay or green manure the yield has been reduced.

CULTIVATION AND UTILIZATION OF BARLEY

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FARMERS' BULLETIN 968

UNITED STATES DEPARTMENT OF AGRICULTURE

*Contribution from
the Bureau of
Plant Industry*
Wm. A. Taylor, Chief

Washington, D.C.

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BARLEY should be more widely grown in the Northern and Western States. It is a protection to our grain supply, as it produces a good, nonglutinous flour and can be milled by wheat mills with little change of machinery.

It is an excellent grain feed for stock, being almost the equal of corn. It, however, competes with corn in few places, as it is mostly grown outside the limits of profitable corn culture. It produces more pounds to the acre than oats or wheat. If necessary, it can be seeded later than spring wheat, and hence interferes little with the wheat acreage in the spring-wheat region. It supplies the needed grain feed necessary for the increase of live stock, which sometime must come with diversified farming in the areas where grain farming is now the only enterprise.

The best lands for barley are well-drained soils that are not sandy. The best returns are obtained from early seeding. The best methods of preparation are fall plowing in the humid-spring region, disked corn ground in the Great Plains, and summer fallow in sections where the crop is winter seeded. The best method of seeding is with a drill, and the best method of harvesting is with a binder. The grain should not be thrashed too close, as broken kernels lower the market value.

The best-yielding varieties are Tennessee Winter in the humid-winter region, Manchuria and Oderbrucker in the humid-spring region, and Coast, Hannchen, Mariout, White Smyrna, Chevalier, and Trebi in the arid region.

CULTIVATION AND UTILIZATION OF BARLEY.

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INCREASING THE ACREAGE OF BARLEY.

THE AREA on which barley may be profitably produced in the United States is more limited than that on which corn, wheat, or oats may be grown with profit. Barley is, however, exceptionally well suited to certain sections and in these sections is a very profitable crop. Its worth is not realized in some localities well suited to its culture. In the West its crop value is appreciated, but throughout the Northern States east of the Rocky Mountains the acreage under cultivation is far too small. In these States it is sound economics to increase the barley acreage for the purpose of producing feed for live stock. On account of the commercial use of barley for malting, its value as a feed is not well understood in these States, nor is the amount of food secured per acre realized by the average farmer. The acreage for stock feed could be greatly extended without prejudice to, and indeed to the advantage of, the maltsters, as there would be a larger offering from which they might choose.

This publication is intended to give a brief statement of the barley areas and the culture and uses of the crop in such a way as to enable the farmer to decide whether or not it is to his individual advantage to grow barley on his farm.

BARLEY REGIONS.

As shown in the accompanying map (fig. 1), the United States may be divided into three general climatic regions, which divisions differ in their economic, varietal, and cultural aspects, as well as their climatic features. These will be designated as the arid, the humid-spring, and the humid-winter regions. In the arid region the period from flowering to ripening is one of scanty rainfall and a very dry atmosphere. In the humid-spring region the same period is marked by frequent summer rains and a humid atmosphere. The humid-winter region is similar to the humid-spring, except that the barley is fall sown. In the arid region, the California crop is winter



FIG. 1.—Outline map of the United States, showing the three general regions of barley production. The dots indicate the acreage of barley, according to the census of 1909. Each dot represents 5,000 acres. (Acreage map from Smith, Baker, and Hainsworth.)

sown, while in the States to the north and east of California it is spring sown.

It will be noted that the arid-humid line does not follow the line of rainfall in the North. This probably indicates a humidity-temperature factor. The southern Plains are much hotter than the northern, which would have a tendency to extend the humid belt in the North and contract it in the South. The line south of Nebraska is purely arbitrary, as barley is not a common crop in the southern Plains. The line separating the humid-spring from the humid-winter region is still more arbitrary. There is a wide belt between the northern limits of profitable winter-barley culture and the southern limits of profitable spring-barley culture in which barley is grown only in especially favored localities.

SPECIAL AREAS DUE TO CLIMATIC VARIATIONS.

The three general regions are subdivided into areas of special characteristics by variations in climate.

In the two humid regions there are few local variations. In the South, winter barley finds very favorable climatic conditions in the mountain areas, especially in eastern Kentucky and Tennessee. The total production, however, is insignificant. In the North some winter barley is produced in the neighborhood of the Great Lakes, especially in Michigan. This is of even less importance than the Kentucky-Tennessee concentration. In New York 2-rowed barleys can be grown with more comparative success than in the upper Mississippi Valley, but they yield less than the best 6-rowed variety.

In the arid region there are many variations, as might be expected from the topography. The Great Plains constitute a subdivision almost equal in rank with the three regions themselves. This area, while of light rainfall, differs from the rest of the arid region in having a summer rainfall which modifies both the conditions of growth and the varieties grown. The entire northern Plains constitute an area especially suited to the culture of 2-rowed barleys, while the extreme southern Plains are more suited to hooded sorts, as are certain localities of high altitude in the Rocky Mountain region. Several counties in northwestern Kansas have a climate unusually favorable to barley production, as is shown on the map (fig. 1).

The Great Basin has features peculiar to itself and distinct from California.

SPECIAL AREAS DUE TO SOIL VARIATIONS.

A study of the map (fig. 1) shows that even in the sections of greatest production, where every climatic feature is favorable, there are localities where very little barley is grown and others where it is almost a predominating crop. This distribution is due to differences in soil.

Barley is very sensitive to soil variation. It demands a well-drained soil, but does not thrive on sands. The projection of barley production into less favorable climates is noticeable in the barley soils which lie along the Mississippi, Missouri, and Arkansas Rivers: The effect of inadequate drainage is apparent in south-central Minnesota, an area favoring barley in climate, where, as shown in figure 1, a poorly drained area separates the heavy-producing sections on either side. Oats give a higher average return than barley in this section. As a rule, soil variations affect the acreage of barley grown, but have little relation to the varieties planted or the methods of production.

ECONOMICS OF BARLEY GROWING.

Barley is grown both as a cash crop and as a feed. West of a line from Bismarck, N. Dak., to Norton, Kans. (about the line of the one hundredth meridian) it is the principal grain feed. East of that line it is usually grown for market. In either case it must compete with oats, and in part of its area with corn. For the most part, barley is grown north and west of the limits of profitable corn culture. Corn, however, may be disregarded, as its cultural requirements limit its acreage to the farm labor available. Where it can be grown it gives higher feed returns than either oats or barley. On most farms, however, the farm management demands at least one spring-sown small grain. As a bread crop, wheat has had an entirely different market, and the cash returns have been in no wise interrelated until the recent demand for wheat substitutes. With the price per pound of barley flour equal to that of wheat flour, barley is much more profitable than wheat as a mill grain. In the absence of a milling demand, the only crop that can be compared readily with barley in farm economy is oats. Both are spring sown, and both are feed crops in that the excess of barley over the malting demands must depend on animal consumption for its market.

TABLE I.—*The average acreage and yields of barley and oats, with the calculation of protein, carbohydrates, and fat in 33 States for the years 1914, 1915, and 1916.*

States.	Acreage.		Yields per acre (pounds).							
			Grain.		Digestible nutrients.					
					Protein.		Carbohydrates and fat (×2.25).		Total.	
	Barley.	Oats.	Barley.	Oats.	Barley.	Oats.	Barley.	Oats.	Barley.	Oats.
Maine.....	5,000	167,000	1,320	1,248	119	121	929	758	1,048	879
Vermont.....	13,000	80,000	1,550	1,251	140	121	1,091	759	1,231	880
New York.....	80,000	1,274,000	1,330	1,050	120	102	936	637	1,056	739
Pennsylvania.....	9,000	1,114,000	1,320	1,056	119	102	929	641	1,048	743
Maryland.....	5,000	45,000	1,584	966	143	94	115	586	1,258	680
Virginia.....	12,000	222,000	1,320	678	119	66	929	412	1,048	877
Ohio.....	33,000	1,683,000	1,340	1,059	121	103	943	643	1,064	745
Indiana.....	12,000	1,654,000	1,278	1,050	115	102	890	637	1,015	739
Illinois.....	56,000	4,371,000	1,526	1,200	137	116	1,074	728	1,211	845
Michigan.....	92,000	1,489,000	1,280	1,130	115	110	901	686	1,016	795
Wisconsin.....	608,000	2,100,000	1,483	1,178	133	114	1,044	715	1,176	829
Minnesota.....	1,334,000	3,197,000	1,160	1,040	104	101	817	681	921	732
Iowa.....	310,000	5,000,000	1,382	1,171	124	114	973	711	1,097	824
Missouri.....	5,000	1,238,000	1,104	774	90	75	777	470	876	545
North Dakota.....	1,542,000	2,422,000	1,070	954	96	93	753	579	850	672
South Dakota.....	808,000	1,727,000	1,243	1,070	112	104	875	649	987	753
Nebraska.....	109,000	2,208,000	1,320	1,060	119	103	929	643	1,048	746
Kansas.....	270,000	1,603,000	1,142	890	103	86	804	540	907	626
Kentucky.....	6,000	242,000	1,350	726	122	70	950	441	1,072	511
Tennessee.....	8,000	356,000	1,195	730	108	71	841	443	949	514
Texas.....	9,000	1,300,000	1,118	950	101	92	787	577	888	609
Oklahoma.....	8,000	1,203,000	1,022	720	92	70	719	437	811	507
Montana.....	82,000	597,000	1,478	1,331	123	129	1,041	808	1,174	937
Wyoming.....	19,000	232,000	1,632	1,194	147	116	1,149	725	1,296	841
Colorado.....	128,000	305,000	1,704	1,194	153	116	1,200	725	1,353	841
New Mexico.....	8,000	59,000	1,650	1,098	149	107	1,162	666	1,310	773
Arizona.....	34,000	9,000	1,728	1,242	156	120	1,217	754	1,372	874
Utah.....	33,000	99,000	1,980	1,498	178	145	1,394	909	1,572	1,054
Nevada.....	12,000	13,000	2,174	1,499	196	145	1,530	910	1,726	1,035
Idaho.....	189,000	326,000	1,880	1,430	169	139	1,324	888	1,493	1,007
Washington.....	174,000	282,000	1,949	1,587	175	164	1,372	963	1,547	1,117
Oregon.....	131,000	363,000	1,679	1,354	150	131	1,176	822	1,326	953
California.....	1,317,000	210,000	1,392	1,072	125	104	980	651	1,105	755

In all the principal barley-growing States and parts of States barley is more profitable and produces more pounds to the acre than oats. Table I indicates that as a matter of farm economy the barley acreage in the northern tier of States should be expanded at the expense of oats. That it is not more widely grown now is due to two causes. Its value as a stock feed is not realized by the farmers east of Montana, and the brewing industry has dominated the market to such an extent that buyers of feed stuff do not think of barley as a feed crop. Barley must be considered as a feed in order to appreciate its true farm value. Not alone pounds, but pounds of digestible nutrients, should be considered.

In Table II the protein, fat, and carbohydrate contents are estimated from the analyses compiled by Henry and Morrison. In order to separate clearly the protein from the fat, the carbohydrates and fat ($\times 2.25$) have been united into a nonproteid factor, which has been used in Tables I and III. The total is the sum of the proteid and nonproteid constituents.

TABLE II.—*Digestible nutrients in each of the common cereals, as determined for animal feeds, according to Henry and Morrison.*

Kinds.	Digestible nutrients (per cent).				
	Crude protein.	Carbohydrates.	Fat.	Carbohydrates and fat ($\times 2.25$).	Total.
Barley.....	9.0	66.8	1.6	70.4	79.4
Oats.....	9.7	52.1	3.8	60.7	70.4
Corn.....	7.5	67.8	4.6	78.2	85.7
Wheat.....	9.2	67.5	1.5	70.9	80.1

The area in which barley often can be profitably substituted for oats is shown graphically on the map (fig. 2). This does not mean that there are no localities in this area in which it is not more profitable to grow oats or that there are no localities outside this area in which it is profitable to grow barley. It does mean that within the area the general climatic and soil conditions are more favorable to large yields of barley than of oats. In Table I the average yields of barley, as may be seen, are higher than of oats not only in the Northern and Western States, but the same is true for many other States as well. In many of these, however, the total production is so small as to be unfair to the oat acreage. Where the barley of a State is largely localized in a section of the State, small acreages have more meaning. A long-established local area is usually based on sound economy, but even here modifications are constantly arising. In the winter-barley section of Tennessee and Kentucky, for example, winter-barley production has been much more profitable than that of oats. The Hessian fly may alter this relation, as barley must be sown before the fly-free date.

Again, in California, barley is much more profitable than oats, when considered as a whole. Either on account of the hay or a local price, it has been estimated ¹ that 161 acres of oats is equal to 167 acres of barley. As a matter of fact, barley and oats hardly enter into competition, as most of the oats are produced on the edge of the barley-growing districts. Wheat is the real competitor of barley in California, as it is more commonly grown on lands well suited to barley culture. Hunt estimates that 235 acres of wheat is equal to 167 acres of barley in income-producing capacity. The progressive de-



FIG. 2.—Outline map of the United States shaded to indicate the area in which the climate is relatively favorable for the production of barley. Within the shaded area, well-drained soils that are not sandy in character produce more pounds of barley to the acre than of either oats or wheat, while corn is a competing crop only along the southern margin. The actual line of separation is quite irregular. Barley culture extends south of the line on favorable soils, as in northwestern Ohio, while oats are more profitable north of the line on soils unfavorable to barley production, as in north-central Iowa and southwestern Minnesota. In the mountain and Piedmont regions of the South there are local areas well adapted to winter barley.

crease in the annual wheat acreage and the progressive increase in the barley acreage sustain these estimates.

The profits of barley are modified by the cultural reason for growing the crop. Often it is not a primary crop but a secondary one, grown because of its special fitness for some abnormal condition. In certain sections, as in northwestern Kansas, it is largely second choice to wheat. If the wheat seeding is successful, wheat is grown. If for some reason the ground can not be prepared for wheat, or if the wheat does not germinate through lack of rainfall, or if the wheat is winterkilled, spring barley is sown as a catch crop. On account of

¹ Some things the prospective settler should know. T. F. Hunt. In Cal. Agr. Exp. Sta. Cir. 121.

its rapid growth and early maturity, barley can be seeded later than other grains. This character is utilized in the spring-wheat area. On lands where spring wheat can not be seeded in time, barley is grown and is sure to give some sort of return.

Barley is often grown on new breaking, as its rank growth tends to subdue the wild grasses. It is commonly used to clean weedy fields, as a good growth of barley smothers many species completely. Its early maturity permits the crop to be cut before many other species have matured seed. Summer fallowing after the harvest destroys many more, and a single season of such treatment results in a marked decrease of the weed population.

Barley is also widely grown on old lands. After land has become too poor to produce good crops of wheat, it is seeded to barley. This sequence has been especially conspicuous in California. In Minnesota and Wisconsin the best barley is produced on old farm lands, which here happen to be of a fertile character. Older lands, where suitable in character and not too depleted, produce a better quality of barley than new lands.

From the standpoint of profit, these various cultural uses of barley must be considered. The returns from a catch crop or a weedy field can not be compared with those of a primary crop, yet a very considerable percentage of the barley acreage is grown on this basis. The figures in Table I would doubtless be more favorable to barley production if there were some way to compensate for these legitimate but hardly comparable acreages.

In general the results of the experiments conducted by the Office of Cereal Investigations are in agreement with the census figures shown in Table I. Table III shows the performance of the best varieties of barley and oats at various stations where cooperative experiments have been conducted. The results in this table have been previously published in various bulletins of the Department of Agriculture,¹ and it is recommended that these publications be consulted for more complete local information.

¹ Cereal experiments at Dickinson, N. Dak. J. A. Clark. U. S. Dept. of Agr. Bul. 33.

Cereal experiments at the Williston Substation. F. R. Babcock. U. S. Dept. of Agr. Bul. 270.

Experiments with wheat, oats, and barley in South Dakota. Manley Champlin. U. S. Dept. of Agr. Bul. 39.

Cereal investigations on the Belle Fourche Experiment Farm. Cecil Salmon. U. S. Dept. of Agr. Bul. 297.

Cereal experiments at the Akron Field Station, Akron, Colo. G. A. McMurdo. U. S. Dept. of Agr. Bul. 402.

Cereal experiments at the Judith Basin Substation, Moccasin, Mont. N. C. Donaldson. U. S. Dept. of Agr. Bul. 398.

Cereal experiments on the Cheyenne Experiment Farm, Archer, Wyo. J. W. Jones. U. S. Dept. of Agr. Bul. 430.

Experiments with spring cereals at the Eastern Oregon Dry-Farming Substation, Moro, Oreg. D. E. Stephens. U. S. Dept. of Agr. Bul. 498.

TABLE III.—*Comparison of the digestible nutrients per acre produced by the best yielding varieties of barley and oats.*

[Compiled from the published reports of experimental farms where tests have been conducted in cooperation with the Office of Cereal Investigations.]

Station.	Average for the years—	Best variety.		Yield per acre.				Digestible nutrients per acre (pounds).					
				Bushels.		Pounds.		Protein.		Carbo-hydrates and fat.		Total.	
		Barley.	Oats.	Barley.	Oats.	Barley.	Oats.	Barley.	Oats.	Barley.	Oats.	Barley.	Oats.
Dickinson, N. Dak.	1907 to 1913	Hanna.....	Early Mountain.	34.9	54.1	1,675	1,731	151	168	1,179	1,051	1,330	1,219
Williston, N. Dak.	1909 to 1914	Manchuria...	Siberian.....			2,088	2,256	188	219	1,470	1,369	1,658	1,588
Highmore, S. Dak.	1906 to 1912	Hannchen...	Swedish Select.	21.0	26.7	1,008	854	91	83	710	518	801	601
Brookings, S. Dak.	1906 to 1912	Odessa.....	Sixty Day..	32.4	43.5	1,555	1,392	140	135	1,095	845	1,235	980
Newell, S. Dak.	1908 to 1913	Hanna.....	do.....	10.7	19.4	514	620	46	60	362	376	408	436
Akron, Colo.	1908 to 1915	Hannchen...	Kherson.....	38.7	44.7	1,858	1,430	167	139	1,308	868	1,475	1,007
Mocasin, Mont.	1910 to 1915	White Smyrna.	Sixty Day..			2,540	2,126	229	206	1,788	1,260	2,017	1,496
Archer, Wyo.	1913 to 1915	do.....	Swedish Select.	21.5	29.6	1,032	947	93	92	727	575	820	667
Moro, Oreg.	1911 to 1915	Mariout.....	Kherson.....			1,646	1,402	148	136	1,159	851	1,307	987

It will be noticed that only at Newell, S. Dak., are the pounds per acre of digestible nutrients produced by barley exceeded by the amount produced by oats. In Washington it was found¹ that in the years 1914, 1915, and 1916 the best variety of barley averaged 3,012 pounds of grain per acre, while the best variety of oats yielded but 2,756 pounds. The average for the State was still more in favor of barley. In experiments carried on by the Office of Cereal Investigations at Chico, Cal., barley yielded decidedly more than oats.

FARMS AND SOILS WHERE BARLEY SHOULD BE GROWN.

Obviously, barley should be grown on those farms where it is more profitable as a cash or feed crop than the other small grains, if the growing of a small grain fits into the scheme of field management. As has already been pointed out, this means large areas in the Northern and Western States and small areas elsewhere. Its profitability or unprofitableness depends entirely on how nearly its optimum requirements of growth are met. Barley is a cool-weather plant. The months of growth in the heavy-producing regions will be found to satisfy this requirement, and the greater part of the crop should be grown in these established areas. Within these areas favorable soils should be chosen.

Barley should not be grown on poorly drained land. Porous soils are preferred. With drainage or light rainfall, heavy soils produce

¹ Barley in Washington. E. G. Schafer and E. F. Gaines. Wash. Agr. Exp. Sta. Bul. 141.

good crops. Sandy soils, even though well drained, are not good barley soils. Clay loams are perhaps the best for barley. While barley produces well on rich, new lands, it can be grown more profitably than wheat on older lands, provided these lands are not too light and are well drained. Farms outside the average limit of profitable production, but still in a favorable climate, which possess desirable soil characters, may be cropped to barley with profit.

THE PLACE OF BARLEY IN THE ROTATION.

Over much of the barley-producing area no consideration is given to rotation of crops. Barley is still grown extensively rather than intensively in most of the Western States. Such rotation as is practiced is with the other small grains and ignores the greater objects of a rotation. Even in this area smaller farms are becoming common, and with the increase of live stock will come a diversification which will permit a cropping system which is now possible only in individual cases. East of the Red River Valley, barley is grown more as a crop of small farms and can enter into a cropping scheme.

In general, barley does best after a cultivated crop. This, in the United States, means corn. In Canada, excellent returns have been secured after root crops. In the United States, our root-crop acreage is limited to potatoes and sugar beets. The total acreage of these available for seeding to barley is too small to be considered. In the humid districts, where diversified farming is practiced, the most feasible rotation is one including corn and a leguminous hay or pasture crop.

Corn, followed by barley (seeded with grass), which in turn is followed by hay or pasture, is the essential combination of a rotation for this area. This is, of course, to be modified to suit local conditions and the nature of the farm. If intended for use as hay, the grass-seed mixture might be timothy and clover; if for pasture, the mixture might include a legume and nonleguminous grasses suited to the locality. If used for hay, the grass mixture would probably stand two years; if for pasture, it might remain a longer time. If grain feed is needed, two years of corn or two of barley might be used. In the case of two years of barley, the second year the barley might be sown at a lesser rate, so as to make a better nurse crop. Wheat may enter any of these rotations by adding one year to the cycle.

Where alfalfa is used, it is seldom profitable to break up the alfalfa land in less than three years, and it is usually profitable to leave it still longer.

In the arid regions corn is a far less common crop. The acreage is increasing, however, and the use of silos is certain to extend it still farther. Investigations have shown¹ that in the Great Plains the

¹ Barley in the Great Plains area: Relation of cultural methods to production. E. C. Chilcott, J. S. Cole, and W. W. Burr. U. S. Dept. Agr. Bul. 222.

largest returns per acre were secured after summer fallow; but on account of the cost of summer tillage, the crops on disked corn ground were much more profitable. Potatoes, where grown, occupy the same place as corn in the scheme of rotation. In eastern Oregon and Washington, and to a lesser extent in Idaho, Wyoming, and Montana, field peas may take the place of both the corn and the hay crop, the rotation probably being peas, wheat, and barley. Much of the barley west of the 98th meridian is certain to be grown without definite rotation until economic conditions have altered considerably. In the South, winter barley occupies the same place as wheat. The best returns are secured after plowing under a leguminous crop, as after cowpeas plowed under the first of September. In the Piedmont region corn in which crimson clover is seeded, crimson clover followed by cowpeas, and barley make a 3-year rotation which can be extended by the use of a second barley crop and, if in a stock-raising region, by the addition of pasture. In the Coastal Plains barley does not succeed well on sandy soils, and stock farming is not common. Where the soils are suitable, corn, cowpeas, and barley may form the basis of the rotation. In some places velvet beans are much better than cowpeas. The advisability of growing barley here usually would depend upon the relative cash returns of wheat and barley. In the South there is a possible exception. Where hogs are raised and fattened on peanuts, barley may be of unusual value in adding firmness to the fat.

MANURES AND FERTILIZERS.

Most of the barley of the United States is grown outside the regions where the use of commercial fertilizers is common. Even barnyard manures are little used in the arid regions. It is likely that the extensive use of both commercial fertilizers and barnyard manures will be confined to the two humid regions for some time to come.

BARNYARD MANURE.

Barnyard manure, when well rotted, is the best farm fertilizer. It not only supplies plant food, but stimulates many desirable forms of bacteria found in the soil. It gives the soil a better texture and a higher moisture-holding capacity. In the humid-spring region it is best applied to the crop preceding barley, preferably corn. In this region the quality of barley often suffers from too much nitrogen, and the straw lodges easily. The addition of a nitrogenous manure causes a ranker growth, which usually results in lodging and difficult harvesting. In the South, where the soil is not so rich, manure plowed under in time to be well decomposed by seeding time is very beneficial.

COMMERCIAL FERTILIZERS.

The use of commercial fertilizers for barley is limited to the eastern part of the United States. It is probable that profits could be secured from their application in sections where it is not a common practice. It is improbable, however, that this is the most desirable way of investing such cash surplus as may be available west of the Mississippi River. The greatest need is, of course, in the South. Lime is the cheapest and most easily procured of the commercial fertilizers. It is not a simple fertilizer, as in the case of nitrogen, for instance, since it is applied to correct acidity and only incidentally to supply calcium. Many of the soils of the humid-winter regions are acid. The use of lime is common throughout the South. Lime can be more evenly distributed with a drill than by hand. In the Eastern and Southern States 1,500 pounds of burnt lime or 3,000 pounds of crushed limestone to the acre can be applied to advantage where lime is needed. The frequency of application depends both on the character of the soil and the nature of the crops grown. Some soils require an application only once in several years, and it is seldom that lime is required more frequently than once in three years. The application should be so timed in the rotation that clover and similar crops are grown upon recently limed soil, while rye and other acid-enduring crops are grown when the supply of lime is lowest.

Applications of lime are doubly important when barley is used as a nurse crop for red clover, which can not be grown on an acid soil.

The three elements usually supplied by the so-called complete fertilizers are nitrogen, phosphorus, and potassium. Nitrogen is commonly secured in nitrate of soda and ammonium sulphate or from such organic materials as tankage and cottonseed meal. Phosphorus is usually obtained in acid phosphate or the raw rock phosphate from which the acid phosphate is manufactured. Basic slag and bone meal, which contain phosphorus, are also widely used. The phosphorus in the acid phosphate is much more available than in the raw rock. The acid form is to be preferred. Raw rock is best used in heavy applications in connection with green manure or in mixing it with stable manures some time before applying it to the field, or sometimes by a daily addition to the stable accumulations. If raw rock is used in a complete fertilizer, the nitrogen can best be added in ammonium sulphate. Potassium can be secured as kainit and sulphate or muriate of potash.

In grain farming complete fertilizers are also used. The formula varies so with the nature and condition of the soil that exact proportions can not be given. Even the basis of the amount removed by the various crops is not particularly significant, because one or more of the three elements in question may be present in abundance.

In general, for grain farming* in the Eastern and Southern States a fertilizer approaching a 3-10-3 formula will be satisfactory; that is, a complete fertilizer with nitrogen, phosphorus, and potassium present in the proportions given.

The aim of every farmer, however, should be to avoid the use of a complete fertilizer. Fertilizers are expensive, and a proper handling of the farm enterprises may cut down their use materially. No farmer should find it necessary to purchase nitrogen. Nitrogen can be secured free from the air by the use of clover, alfalfa, cowpeas, soy beans, velvet beans, or vetch. Any scheme of crop management should embrace one or more of these crops. The rotation mentioned earlier provided for supplying nitrogen by this means.

Potash is usually present in sufficient quantity, though not always available. Green manures and barnyard manures tend to make potash available. The same scheme that adds the nitrogen will ordinarily free sufficient potash for the needs of the crop. Phosphorus alone is the element that may need to be supplied direct to farms of the East and South. The more live stock enters into the management of the farm, the less phosphorus will need to be added. The scheme of adding phosphate to the stable manure is ideal, but seldom sufficient. Only the most specialized of live-stock farms produce enough manure to cover their entire area in any reasonable number of years. Green manures and legumes must supplement these applications; and to them, in certain areas, phosphates must be added to maintain a high productivity.

GOOD SEED.

Good seed is an insurance that the crop makes its initial growth without handicap. It means a good deal more than merely seed that will grow. It means seed that will grow vigorously and mature a desirable sort of grain that is free from disease.

To secure such seed it must be, first, a desirable variety. The varieties are discussed later. It must be from a field that was properly cared for the previous year. The grain should have been well matured and so shocked and stacked that it escaped weather and heat damage. Grain that has passed through the sweat in the stack germinates more vigorously and in higher percentage than that thrashed and placed in the bin immediately after cutting. Weather damage in the shock seriously injures the vitality of the seed.

The grain should be free from weed seeds and diseases. Noxious weeds are often introduced on the farm through the seed. It is much cheaper to pay a few cents a bushel more for certified seed than to use seed of doubtful character. It is better to get seed from clean fields than to treat it for diseases. Where diseases are present in quantity they should be treated or disease-free seed obtained.

Seed that is otherwise desirable often has a percentage of poorly developed kernels. These can be removed with a fanning mill. While good plants can sometimes be secured from small seed, they are likely to be weak and are usually crowded out. It is best to remove the lighter grain and use it as feed. The fanning mill, while performing this function, will at the same time remove many kinds of weed seeds.

PREPARATION OF THE SOIL.

The ideal seed bed is one in which the bottom is firm but not too hard for the easy penetration of water and the growth of roots, while the upper 2 inches are loose. The soil should be so firm that



FIG. 3.—Drilling grain on a well-prepared seed bed.

few grains will fall in spaces too large to secure the contact with moist surfaces necessary for germination and thus result in an uneven start. The right kind of a seed bed is shown in figure 3.

The aim of the operations in seed-bed preparation is to approximate the ideal seed bed at the least possible cost. Very comprehensive data on seed-bed preparation in the Great Plains area have been published by the United States Department of Agriculture.¹ While not directly applicable to other barley-growing districts, the figures are so suggestive that one of the tables is copied entire in Table IV of this bulletin.

Both production and profits are shown. These, of course, vary from day to day. The price used as the basis of cost computation in Table IV is 41 cents per bushel in the shock. At that price disked

¹ Barley in the Great Plains Area. E. C. Chilcott, J. S. Cole, and W. W. Burr. U. S. Dept. Agr. Bul. 222.

corn ground was found to be the most profitable on the Great Plains. In the humid-spring areas disked corn ground or fall plowing is probably the cheapest. From the point of returns, fall plowing is best in this region. In the Dakotas preference is frequently given to wheat, and the barley crop is placed on late spring plowing, which is harrowed and planted at once. Necessity justifies this practice, as it is often the only possible way to put in a crop. When this is done, all the labor which can be given without sacrifice of acreage should be devoted to the reduction of the soil to a firm condition.

TABLE IV.—Comparison of the average yields and profit or loss in the production of barley by different methods of tillage at 14 stations in the Great Plains area.

[Data according to Chilcote, Cole, and Burr. The profits and losses were based on prewar prices for equipment and labor, and a farm price of 47 cents per bushel for barley.]

Statement.	Number of years averaged.	Methods of tillage.						
		Fall plowed.	Spring plowed.	Listed.	Sub- soiled.	Disked.	Green manured.	Summer tilled.
Yields per acre (bushels):								
Judith Basin, Mont.	5	24.0	24.0	29.0	30.5	29.0		30.2
Huntley, Mont.	2		29.6			34.5	43.8	
Williston, N. Dak.	5	17.4	16.1			27.5		24.8
Dickinson, N. Dak.	6	25.1	24.6			37.4		32.5
Edgeley, N. Dak.	8	16.7	18.5			23.4		20.0
Hettinger, N. Dak.	3	19.9	25.5			14.9		31.8
Belle Fourche, S. Dak.	6	7.6	8.3	7.7	8.0	12.2		12.6
Scottsbluff, Nebr.	2	14.0	15.4	14.4	15.0	18.6		27.6
North Platte, Nebr.	8	17.1	15.9			13.4		26.7
Akron, Colo.	6	18.6	18.8	17.9	14.0	18.4		24.8
Hays, Kans.	6	13.6	11.2	12.7	14.6	14.1	15.5	19.3
Garden City, Kans.	5	6.9	4.3	8.3	6.9	8.9		11.0
Dahart, Tex.	4	3.9	1.9	4.4		1.6		6.4
Amarillo, Tex.	6	8.2	5.7	6.1	6.8	6.6		12.6
Profit or loss (—) per acre:								
Judith Basin, Mont.	5	\$3.38	\$3.85	\$6.44	\$5.44	\$7.24		\$0.98
Huntley, Mont.	3		6.15			9.50	\$3.45	
Williston, N. Dak.	5	.67	.61			6.63		.41
Dickinson, N. Dak.	6	3.83	4.10			10.68		1.93
Edgeley, N. Dak.	8	.39	1.60			4.94		-3.20
Hettinger, N. Dak.	3	1.70	4.47			1.46		1.64
Belle Fourche, S. Dak.	6	-3.34	-2.59	-2.29	-3.79	.35		-6.23
Scottsbluff, Nebr.	2	-.72	.32	.45	-.92	2.98		-.08
North Platte, Nebr.	8	.55	.53			.84		-.55
Akron, Colo.	6	1.17	1.72	1.89	-1.33	2.89		-1.23
Hays, Kans.	6	-.88	-1.40	-.24	-1.08	1.13	-8.15	-3.49
Garden City, Kans.	5	-3.63	-4.23	-2.05	-4.24	-1.00		-6.89
Dahart, Tex.	4	-4.86	-5.21	-3.65		-3.99		-8.78
Amarillo, Tex.	6	-3.10	-3.65	-2.95	-4.28	-1.94		-6.23

In California plowing is usually delayed until the fall rains begin. Much of the sowing is on land that is plowed in January or February and even in March. The seed bed is frequently far from ideal. After summer fallow the seed bed is good and needs no modification. In fall plowing, advantage should be taken of all the early rains and a seed bed prepared as early as possible. The disk can be used after the first rain and the ground made more receptive and the plowing easier. The custom of volunteer crops should be discontinued. Disked land should be used only when there is not time for plowing, as early seeding is an important consideration in California except on subirrigated lands.

In the South, winter barley is seeded after a variety of crops. Although good results are sometimes secured after corn, that crop is too late in maturing to prepare the soil for the best time of seeding. For this reason it is not advised. If seeded after corn, a disk is the best implement for preparing the seed bed.

When barley follows a small-grain crop the land is frequently plowed immediately after harvest and allowed to lie fallow until fall. Cowpeas can be grown to advantage after a winter grain and turned under as green manure. In this case the ground should be plowed some time before seeding, to allow it to settle as much as possible. If the pea crop is removed for hay, disking is preferred to plowing.

DATE OF SEEDING.

The maximum returns from barley are obtained when the crop is seeded early. The fact that spring barley can be seeded quite late and still mature a partial crop has led to considerable abuse of the latitude that its early maturity makes possible. It is the common practice to seed barley after the seeding of oats and spring wheat has been completed. From the farm standpoint this practice is justified by the requirement that the oats and wheat must be sown early. From the standpoint of barley culture it is not good practice and results in reduced yields. As a matter of fact, spring barley should be sown at about the date generally observed for sowing spring wheat, if the best results are to be obtained. In certain localities where the spring opens late this is not always possible, but the losses arising from late seeding should be realized and all efforts made to hasten the spring work. Large grain farms, such as are found in North Dakota, present the most difficult problems. The work on all crops falls in a very short period, and if weather conditions are adverse it is not physically possible to complete the seeding during the period when the best results are to be obtained. It has been shown¹ that the period of barley seeding in North Dakota extends over 25 days, while in Wisconsin the seeding is accomplished in 16 days. This means that in Wisconsin barley is a primary crop, grown on farms so small and so diversified that the farmer grows it for the sake of the barley crop and is able to seed it near the proper time for seeding barley. In North Dakota, on the contrary, barley is seeded when the wheat and oats seeding permit. In Wisconsin the greater part of the crop is seeded during the most favorable period. In North Dakota most of it is seeded later than this period.

Of course, there is variation from season to season, but, in general, barley should be seeded as early as the ground can be well worked in the spring. If the soil is of a heavy, cold character, it should be

¹ Seedtime and harvest. J. R. Covert. U. S. Dept. Agr., Bur. of Stat. Bul. 85.

seeded a little later than the lighter soils, as the soil must have some warmth at seeding time. The recommendation of early seeding should not be followed to such an extreme as to plant the grain in a backward spring in soil that must be worked wet to prepare it for such early date. Neither should the ground be allowed to remain weedy in order to hasten the date. On the other hand, no time should be lost when the ground can be worked with safety, especially if it has acquired some warmth. In the northern Plains, the most favorable period is from April 1 to April 25. Figure 4 indicates the yields according to time of seeding in Montana, North Dakota, and South

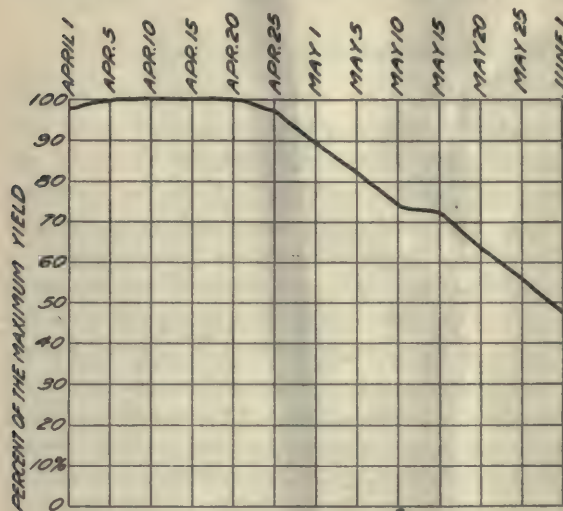


FIG. 4.—Diagram showing the percentage of the maximum yield that has been obtained on various dates of seeding at field stations in North Dakota, South Dakota, and Montana. Seeding later than April 25 has resulted in a loss of more than 1 per cent for each day that seeding was delayed. Seeding the last of May has given only about 50 per cent of the maximum yield. In southeastern Minnesota and Wisconsin, the best date to seed is correspondingly earlier.

Dakota, from data made up from the experiments at a number of stations. In only one instance at one station did the earliest date produce less than the maximum yield. After April 20 the yields began to be somewhat less, and in no case did seeding as late as the first of May produce a maximum yield. The loss after April 25 is more than 1 per cent a day. These tests were all in well-prepared seed beds, and it is possible that the earliest seedings on soil that is less well

prepared might not produce results as favorable as those here shown. It is certain that the falling off in yield would show as quickly on any seed bed, owing to less favorable climatic conditions during the ripening period.

The loss of at least 1 per cent a day after April 25 must be reckoned as a probable average for a series of years. This means that on a field of 50 acres of barley which if seeded in time would yield 30 bushels per acre, there is a loss for the field of at least 15 bushels a day for every day that seeding is delayed beyond April 25. This is the average date for these States. In Montana and the extreme northwestern portion of North Dakota the date is three or four days later, and in some parts of South Dakota it is three or four days

earlier. The variation is not as much as would be expected. The seasons in southern Minnesota, Iowa, and Wisconsin are slightly earlier, and the consequences of late seeding are more disastrous than in the case of the other States mentioned. Seeding as late as the first of May in southern Minnesota and Wisconsin is to be discouraged. In New York and New England the cool summer permits a slightly later seeding. In Oregon and Washington, spring-sown barley should be put in as early as possible. In California, data collected by G. W. Hendry show that early seeding (before Dec. 20) produces the maximum yields, while late seeding (after Jan. 25) shows a yield more than 20 per cent less than the earlier date.

In the Southeastern States winter barley must be seeded early. September seeding has given good results at most places in the barley-producing area. In the southern edge of the humid-winter belt, October seeding is frequent.

RATE OF SEEDING.

The best rate of seeding barley varies widely with the season, and maximum yields are obtained at rates covering a wide range. A single plant accommodates itself to its individual conditions. If it is crowded by other plants, it produces only one or two culms, but in an open space it may produce several. The best rates are usually heavy enough to insure that the thinnest spots on the field will have enough plants for a maximum yield. In the humid regions this maximum under favorable conditions might be obtained with a seeding of 5 pecks per acre, yet at the same time 10 pecks per acre would not decrease the yield. As the seed bed is not usually perfect and as adverse weather conditions subsequent to seeding may decrease the stand, 2 bushels per acre are usually seeded in the humid sections. In the northern Plains 4 pecks per acre have given about the same returns as 8 pecks. Four to 6 pecks are usually recommended. Six pecks are too much in the driest years and in localities where the average season is known to be severe. Four pecks are recommended for such places. In other parts of the northern Plains, especially along the eastern limit, 6 pecks may often be sown to advantage, though it is usually more than is necessary if the seed bed is in prime condition. In the very driest localities of the Dakotas and Montana and in the Great Basin, 3 pecks are sometimes seeded to advantage. In California, 7 pecks per acre are usually seeded. In the winter-barley district of the Southeastern States 8 pecks are recommended. Where a naked variety is grown, not more than three-fourths of the rate for hulled barley should be sown. Where barley is grown as a nurse crop, about 25 per cent less grain should be seeded than for a grain crop, as a thin stand allows a better growth of forage plants, a good stand of which is shown in figure 5. When grown for pasture, the rate should be increased 25 to 50 per cent.

DEPTH OF SEEDING.

The seed of barley should be placed in the ground at such a depth that it can secure both moisture and air. In the humid regions, if planted too deeply, excessive moisture may shut off the air supply and reduce the temperature to the extent of decreasing the germination. In the arid region, too shallow planting may result in poor germination through lack of moisture. In the humid regions, the best conditions are found at a depth of about $1\frac{1}{2}$ inches. In the northern Plains this should be increased to 2 inches. In the Great



FIG. 5.—A field showing winter barley as a nurse crop for red clover.

Basin the best depth is from $2\frac{1}{2}$ to 3 inches. At Nephi, Utah, 3 inches was found to give the best results for the depths tried, but no seeding was made at $2\frac{1}{2}$ inches.

METHOD OF SEEDING.

Drilling with a grain drill is the best method of seeding barley. The drill is constructed for the purpose of placing every seed in the most favorable location. For this reason it is much more economical of seed than broadcasting. Under favorable conditions of soil and moisture, broadcasting may produce yields as high as those obtained

from drilled seed. As the conditions become adverse, the results are more and more in favor of drilling. In the drier regions the grain must be placed at some depth beneath the surface to secure an even germination. This can not be done uniformly by any means except the drill. Any good grain drill will do the work successfully on a well-prepared seed bed. If the ground is covered with trash, as disked corn ground, the single disk drill is to be preferred.

Broadcasting should not be practiced where it can be avoided. It is particularly undesirable to broadcast seed on dry ground, as part of it may be harrowed in deep enough to secure germination, while the rest may lie for days awaiting a rain to start growth. This results in a very uneven stand. In moist soil, under favorable conditions broadcasting is not so objectionable. In the interior valleys of California where the plowing, seeding, and harrowing must be done quickly, before the rains begin, broadcasting is often employed to save time. Even here, although conditions are unusually favorable to broadcasting, better results are obtained with a drill, and where the ground is in suitable condition and sufficient equipment is available to seed the acreage without delay, a drill should be used.

TIME OF HARVESTING.

The time of harvesting barley depends on the use of the crop, the variety, the climate, and the method used.

For seed, brewing, or feed, the crop should be mature. The maturity should not be judged by the earliest spikes. If possible, the latest spikes should be mature, as this will insure that no part of the crop will be shrunken from having been harvested too soon. If the stand is thin or uneven, this may not be possible, as the earlier spikes of many varieties would begin to shatter. By maturity is meant the point where material ceases to be added to the kernel and not that the grain has become dry. There are several popular tests which indicate this period. The kernel at this time can be dented with the thumb-nail and retains the dent for some time. The milky juice largely disappears from the furrow. The hull begins to wrinkle on the ripest grain, showing the shrinkage of the kernel beneath. After this point is reached, ripening is merely the loss of moisture and can take place in the shock as well as if left uncut.

Nurse crops of barley are often cut somewhat earlier than grain crops, but this is for the purpose of favoring the development of the grass seeded with the barley and does not enter largely into the general problem of barley harvest.

As a hay crop barley is harvested still earlier. It is not, however, cut while in bloom, as is customary with many of the grasses. The grain is allowed to develop almost to its maximum. The grain content of barley hay constitutes a considerable part of its feed value.

Barley is highly prized as a hay crop in the West, despite the coarse awns which frequently cause sore mouths in horses and cattle. Sometimes the hooded varieties are grown for hay, in order to eliminate this objectionable factor. Much of the hay, however, is incidental; that is, the barley is sown for grain. If the season is favorable, it is harvested for grain; if unfavorable, it is harvested for hay.

The time to harvest sometimes depends on the variety. Some varieties shatter badly when ripe, while others do not. Hooded and awnless sorts shatter most easily. The Coast type (Bay Brewing, California Feed, etc.) shatters much less than the other types. The types which shatter must be harvested promptly. The best of the Coast type can be left until the full maturity of the latest culms and suffer but moderate losses for some time after complete dryness.

The climatic conditions at the time of harvesting have some influence on the stage at which barley is cut. In a section subject to storms the harvest must be accomplished within a very few days. If the straw is too green it will not dry out properly in a humid climate and there may be mold damage. If harvest is delayed too long much grain might be lost through the occurrence of a storm, as all barleys in humid climates shatter rather easily. In the arid region, green barley dries out readily and storms are not so common as to cause shattering in the overmature crop. The varieties in the arid regions outside the Great Plains do not shatter readily.

METHODS OF HARVESTING.

There are but three common methods of harvesting barley, by the use of the binder, the header, and the combined harvester. The grain binder is the implement of the intensive farmer and is by all means the best where it can be used. The grain can be cut with less loss. It can be cut at the optimum time and in the humid regions can be stored with less damage than by the other methods. When cut with the header or the combined harvester, the grain is allowed to ripen more completely than when cut with the grain binder.

The header is important in the Plains, where it is a rapid means of harvesting large acreages. It is very useful in harvesting crops where the straw is too short for the best use of the binder. Some varieties, such as the White Smyrna, are very difficult to harvest with a binder, on account of their short straw. The common use of the combined harvester is confined to the Great Basin and California.

When the combined harvester is used the grain must be ripened to dryness. In California the crop often stands three weeks after maturity before being cut. Only varieties of the Coast and Mariout types are suitable for this practice. None of the other common varieties will stand after they are ripe without losing a large part, probably the greater part, of the grain. In California, in a total yield of 31.1

sacks per acre, there was a loss of 6.6 sacks per acre when the combined harvester was used, while only 1 sack per acre was lost when the grain binder was used.¹ This loss of 1 sack included the loss at the thrasher. The loss of the crop by the use of the combined harvester was 21 per cent, while that of the binder was 3 per cent. Prof. Hendry states that although it might be held that the shattering loss was unusually high in this case because the yield was above the average, observations made in various parts of the State would indicate that the contrary is true and that the percentage of shattering is usually higher in the case of the lower yields. He also states that, while the cost of production is lower with a combined harvester, the net proceeds are in favor of the use of the grain binder.

The grain lost by shattering is sometimes allowed to volunteer for the next crop. This practice is not to be recommended, as it is unprofitable.

SHOCKING, STACKING, AND THRASHING.

Grain is usually shocked after being cut by the binder. The object of shocking is to protect the grain as far as possible until it is thrashed. The treatment of course varies with the climate of the section. The more humid the section, the more trouble is experienced in safely harvesting the crop. Weather is the main source of shock damage. The shocks should be built with this in mind. If the straw is not quite dry, oblong shocks without caps are best. If the section is one where windy weather prevails, the grain may be left in this form of shock until stacked or thrashed. In the rainy districts, winds permitting, these oblong shocks should be changed to the round type and capped when dry. Ordinarily, of course, the grain is dry enough to put in a round shock and be capped at once. After heavy rains, if the shocks have become wet inside, they must be opened and the bundles spread out to dry. The bundles should be laid across one another in such a way as to keep the heads off the ground.

The grain should stay in the shock as short a time as possible. Rain is certain to discolor and injure the cap sheaves. If the bundles become wet enough to require spreading, most of the grain will be discolored at least. There are various species of fungi that aid in the discoloration, and if the grain remains moist any length of time odors of mold will persist after thrashing. Discoloration and mold odors greatly lessen the price when the grain goes on the market as malting barley. Weather damage, aside from the direct loss of germinated grains, affects the viability of the seed and its value for seed and malting purposes. For these reasons the grain should be either stacked or thrashed as soon as possible after it is cut. Stack-

¹ Harvesting grain in California. G. W. Hendry. *In Jour. Agr., Univ. Cal., v. 3, no. 4.*

ing gives the finest quality of grain for seed or malting. The grain goes through the sweat in the stack, which seems to increase the percentage and vigor of germination. Sweating also occurs in bin grain thrashed from the shock soon after cutting. Bin sweating is not as normal as that in the stack and there is some danger of heating. There is some loss of weight in sweating, and properly cured barley should bring a higher price than grain direct from the field. It costs about 1 cent per bushel more to stack grain than to thrash from the shock. When grain is stacked the work should be carefully done and the stacks made in such a way that they shed water perfectly. Poor stacking may result in large losses. Unless skilled labor is available, it is better to stack under sheds or other shelters, if it is possible to do so.

Barley must be thrashed carefully. About one-fourth of the crop is used for malting. Its value for this purpose can be greatly affected by improper thrashing. In the process of malting, barley is germinated at temperatures and in a humidity favorable for fungous growth. The grains are protected by a heavy layer of cells that surround the starchy interior. If this layer is injured the fungi gain entrance and feed upon the material stored in the grain. Injury in thrashing comes about in two ways: Many kernels are actually broken in half, and many others are thrashed too close. Close thrashing breaks off the tips and exposes the body of the grain to attacks of fungi. The concaves should be so set as to avoid these injuries.

COST OF PRODUCING BARLEY.

The cost of producing barley varies with the section of the country, the cost of man and horse labor, the price of seed, and the amount of capitalization. These items themselves vary from year to year in any section. At present the cost is considerably higher than it was even three years ago.

In Table V is given a compilation of the data published by several investigators.¹ Their work represents the three general areas which present marked differences of economic conditions and cultural practices. The farms of the humid-spring region, where land values are high and the agriculture more or less diversified, are represented in the Minnesota averages. In the Great Plains land values are low, with grain farming the main enterprise. In California land values are about the same as in Minnesota. The barley is raised on farms devoted almost exclusively to grains and is usually harvested with the combined harvester.

¹ Barley in the Great Plains area. E. C. Chilcott, J. S. Cole, and W. W. Burr. U. S. Dept. Agr. Bul. 222, p. 13.

The cost of producing Minnesota farm products. F. W. Peck. Minn. Agr. Exp. Sta. Bul. 145.
Harvesting grain in California. G. W. Hendry. In Jour. Agr., Univ. Cal., v. 3, no. 4.

TABLE V.—*Prewar cost of producing an acre of barley in three representative sections of the United States.*

Locality and method of preparation.	Method of harvesting.	Preparation of land.	Seed.	Seeding.	Cutting and shocking.	Interest, taxes, depreciation, and general expenses. ¹	Total cost of grain in shock.	Stacking and thrashing.	Total cost, thrashed grain.
Minnesota: ²									
Fall plowed.....	Binder.....	\$2.08	\$1.58	\$0.31	\$0.81	\$5.37	\$10.15	\$1.93	\$12.08
Great Plains area: ³									
Disked corn land.....		.97	.75	.40	.93	1.60	4.65		
Listed.....		1.77	.75	.40	.93	1.60	5.45		
Spring plowed.....		2.31	.75	.40	.93	1.60	5.99		
Fall plowed.....		2.78	.75	.40	.93	1.60	6.46		
Subsoiled.....		3.39	.75	.40	.93	1.60	7.07		
Summer tilled.....		6.12	.75	.40	.93	3.20	11.40		
California: ⁴									
Fallow.....	Binder.....	1.75	1.00	.40	1.55	11.17	15.87	4.30	20.17
Do.....	Combined harvester	1.75	1.00	.40		11.17			17.72

¹ The sums given in the column of interest, etc., in the case of the Great Plains region include only interest and taxes and not depreciation and general expenses.

² Average of farms in three localities during the years 1908-1912, according to Peck.

³ Average of eight stations in the Great Plains area, during the years 1909-1914, as given by Chilcott, Cole, and Burr.

⁴ Cost based on a 31-sack crop in 1915, according to Hendry.

In Table V some liberties have been taken with the figures of the various investigators. Hendry's figures, for example, were originally a comparison of the two methods of harvesting. He carries the cost to the place where the barley is in the warehouse. In the cost of thrashed grain he includes sacks. These are omitted here because the figures would not then be comparable with those of the other investigators. As far as California is concerned, they should be included. Hendry's total cost in the warehouse was \$22.79 for the combined harvester and \$26.13 for the grain binder. Much of the extra cost of the binder comes from the extra quantity of grain handled, $5\frac{1}{2}$ sacks more being secured by the use of the binder than by the use of the combined harvester. The net profit per acre is greater with the grain binder.

In the cost per acre of grain in the shock the variations are of interest. The grain in the shock is the fairest point of comparison, as Chilcott, Cole, and Burr do not carry their figures farther. The overhead charges of Peck are just about one-half those of Hendry. In Minnesota a crop is raised every year, while in California a crop of 31 sacks could not be expected except when the land was fallowed every alternate year. The overhead charge of Chilcott, Cole, and Burr in the Great Plains is low, owing to low land values and to the inclusion of part of the depreciation in the labor cost. The overhead charge is the largest single item and the one commonly ignored by farmers who own their own land and equipment. Farmers usually figure their profit without considering either the interest on their

investment or their own labor. In most of the barley-growing districts a satisfactory margin exists between the cost of production and the cash returns. From the current price of barley the number of bushels necessary to meet the cost of production is readily computed. It is the grain in excess of this quantity that constitutes the profit of the farmer. As the cost of farm labor and materials has advanced greatly during the war the farmer must add this extra cost in making estimates at present.

USES OF BARLEY IN MANUFACTORIES.

The market price of barley depends in part on its suitability for the use to which it is to be put. The factory markets are for malting, pearling, breakfast-food preparation, and flour. The maltsters require a clean, well-matured, undamaged grain of high viability. Damage may result from either harvest, shock, bin, or thrashing injury. Barley that is cut too soon—that is, before the grain is really mature—is usually classified as harvest-damaged grain. Shock damage arises from adverse weather conditions. This has been previously discussed and need not be repeated. Bin damage comes from the storage of moist barley or from leaks after storing. On the farm about the only remedy for bin heating is shoveling the grain to another bin when it heats. If floor space is available, spreading it out over a large area and shoveling it over every day or two will save very moist grain from injury. In elevators it is comparatively easy to aerate grain by running it into another bin. Musty barley makes musty malt and musty malt carries objectionable flavors into the malt liquors when used for that purpose. Thrashing injuries promote the growth of molds in the germinating chambers. Carefully thrashed grain is of more value to the maltster than poorly thrashed grain.

Barley that is raised for malting should be of the variety or at least the type common to the region, unless previous arrangements have been made with the buyer and there are facilities for keeping it separate. A mixture of types is a sure cause for a decreased yield to the maltster. Different types germinate differently and can not be malted uniformly when mixed.

Pearled barley is made by the removal of the outer portions, leaving a round pellet which is free from hulls and bran. Barley for this purpose must be free from weather damage and unbroken, as it is impossible to pearl a broken kernel. The larger and more nearly spherical the kernel, the more economical is the process and the better the product. For these reasons large-grained 2-rowed varieties are grown for pearling. The best variety is the Chevalier. This variety can be grown well in Montana and the Great Basin under irrigation and sufficiently well in the delta lands of California. Where the Chevalier does not grow well, the Hanna may be substituted.

Most barley breakfast foods are made from malt. Their requirements, therefore, are those of malting barley. If naked barley were grown in large enough acreages in definite localities, it is possible that a better market for it might be secured for special purposes.

Barley flour is new to this country, but the experience of 1917 has shown that in cases of wheat shortage it is a valuable reserve flour grain. Barley is usually seeded later than wheat and interferes little with the wheat acreage. It is a protection to our wheat supply, in case it is needed as a substitute for wheat flour. It can be milled by wheat mills and produces more pounds of flour per acre than wheat.

Barley flour when used alone does not make good raised bread. It can be mixed up to 20 per cent with wheat flour, without detriment to the quality of the bread. For hot breads where baking powders are employed 80 per cent of barley flour may be used.

The future of barley flour in America depends, to a considerable degree upon other factors than its nutritive and baking value. Unquestionably, barley flour is nutritious, and it mixes very well with wheat flour in the making of bread. The addition of barley flour darkens the loaf, and this is the main obstacle to its regular use. The American housewife prefers a white bread, even at the expense of some food value. Although barley will not make as white a loaf as wheat, the desire for light color can be partially met by careful milling and the use of selected varieties.

Undoubtedly the first barley milled in this country was of too high extraction to be permanently satisfactory. The flour was nutritious and probably contained a large amount of desirable mineral elements, but the dark color caused dissatisfaction. As high as 70 per cent of flour was often secured, when the percentage, from the trade standpoint, should have been not more than 60 per cent, and probably should have been less. Machinery or methods that completely eliminate the glumes and other enveloping tissues before or after grinding will doubtless add much to the appearance of the flour. In using the so-called blue varieties it may be necessary to remove the aleurone layer as well.

Some varieties are better suited than others for milling. Less waste occurs with large-grained varieties than with small-grained ones. If grown for milling, the sorts with white aleurone layers are preferable to those with blue aleurone layers. The Chevalier is perhaps the best variety for milling that is grown extensively at present. The White Smyrna and Hannchen are suitable varieties, adapted to definite sections mentioned elsewhere. Until there is a definite market preference which carries with it a noticeably higher price per bushel, the farmer can not be expected to sacrifice high-yielding varieties for those less well adapted. Where large-grained varieties with white aleurone layers produce as much as those with smaller

grains or blue aleurone layers, the farmer may readily anticipate the demand by seeding them in preference.

STOCK FEED.

The value of barley as a feed is not appreciated by the eastern farmer. In the West where corn is not grown, barley is utilized and is fed understandingly. In the humid region its possibilities have been so obscured by the habit of corn feeding that barley is hardly considered in live-stock farming. On account of the high acre yield of corn, barley can not compete with corn where labor is sufficient to make corn the exclusive grain crop. Where small grain is raised as a part of the farming program, barley is often the most profitable. The sections where this is likely to be the case are indicated on the map (fig. 2). Where grain is to be purchased to supplement the farm production, barley by all means should be considered. Pound for pound, its relative value is shown in Table II. Its value as a feed is not entirely revealed in the table, since the suitability of different grains to different classes of live stock does not depend entirely on their chemical composition. Oats, for instance, are unsuited to the feeding of pigs because of the large amount of hull. Barley, on the contrary, can be used with success and is especially prized for the production of bacon. Barley, on account of its high protein content, is usually better for growing stock than corn, while corn is usually superior for a fattening ration. The following statement¹ indicates the value of barley as a feed:

On the Pacific slope, where corn or oats do not flourish in equal degree, barley is extensively used as a feed for animals. The horses of California are quite generally fed on rolled barley, with wheat, oat, or barley hay for roughage. Barley is the common feed for dairy cows in northern Europe. The Danes sow barley and oats together in the proportion of one part of barley to two of oats, the ground mixed grain from this crop being regarded as the best available feed for dairy cows and other stock. Fed with legume hay to fattening steers and lambs, barley has given nearly as good returns as corn. For horses, barley is somewhat less valuable than oats. At the Virginia station,² calves made excellent gains on barley and skim milk, but corn proved cheaper. In Great Britain and northern Europe barley takes the place of corn for pig feeding, leading all grains in producing pork of fine quality, both as to hardness and flavor. In American trials somewhat more barley than corn has been required for 100 pounds gain with fattening pigs. * * * Though barley is somewhat higher than corn in crude protein, it is still decidedly carbonaceous in character and should be fed with legume hay or with a nitrogenous concentrate for the best results.

The food value per acre for barley has been indicated in Tables I and III, in which the pounds per acre have been multiplied by the percentages of protein and carbohydrates to show the pounds of digestible nutrients. Corn, on account of the high yield, gives higher returns than barley in the sections where corn can be grown.

¹ Feeds and feeding. W. A. Henry and F. B. Morrison. 1915 edition, p. 162.

² Grains to supplement skim milk for calves. J. R. Fain and M. P. Jarnagin. Va. Agr. Exp. Sta. Bul. 172, pp. 81-94.

FEEDING BARLEY.

Success with barley depends in part on how it is fed. Barley fed whole is too hard for the best results, as much of it remains undigested. If barley is finely ground, it makes a pasty mass in the mouths of the animals, which is evidently disagreeable, since they consume much less grain and consequently put on less flesh. The grinding machinery should be so set that the grain is merely cracked and not ground to the fineness of meal or flour. Where it can be done, a desirable method of preparation is rolling. Rolled barley is used throughout the West and should become common in the upper Missouri and Mississippi River valleys. In the latter regions the feeding of barley is much less common than it should be. Throughout this area barley is easily grown and can readily furnish the grain feed in a better balanced system of farming. It is desirable that a greater number of live stock be kept on the farms. Grain farming at usual prices is yielding gradually decreasing returns on some of the best farming lands, and it has been extended into regions where it is not and probably can not be made continuously profitable. The hope of improvement in each case lies in live stock. For adequate live-stock husbandry a carbonaceous grain is necessary. Much of the area is beyond the limit of corn for grain, though it is profitable for silage. Barley has a real place in establishing this area on a firm economic footing.

Barley is a good grain feed; cracked barley is better, and it is believed that rolled barley is still more desirable. The rolled product is shown in figure 6. Any pair of heavy rolls will do the work. In the West there are large central mills which roll barley for a moderate charge. In these large mills the grain is steamed by a jet of live steam entering the stream of barley just before it reaches the rolls. The steam does not have time to penetrate the grain, which is in no way cooked or wet but merely moistened. The moisture thus added prevents any disintegration of the kernel and causes it to be merely flattened.

There are small outfits on the market for rolling barley on the farm. In these there is no provision for steaming, and the product is in consequence not quite so desirable. Such outfits, however, may prove especially useful in the humid sections of the United States, where steaming might lead to storage difficulties.

PASTURING BARLEY.

Winter barley is sometimes used for pasture in the South, but is of minor importance compared with winter oats or rye. When intended for this purpose, it should be seeded earlier than for a grain crop, so that the plants may become well established before the first

cold weather. A heavier seeding than for a grain crop is desirable. Drilling is preferred to broadcasting. Barley is also used occasionally as a cover crop in this region.

VARIETAL REGIONS.

The varieties of barley grown are grouped readily on the basis of the regions of production indicated on the map (fig. 1). While some of the varieties that do well in the humid-spring area can be grown successfully in the arid regions, those typical of the arid region, especially the sections of the Great Plains, do not do well under humid conditions. Barley from neither of these regions does well in the



FIG. 6.—Rolled barley: A common way of preparing barley for feed in the West.

humid-winter region. Each of these three regions is characterized by a predominating commercial type that is more or less well adapted to the whole area and that is almost certain to yield well wherever planted. In present practice the outstanding variety of the arid region is the Coast barley (sometimes known as California Feed or Bay Brewing), but it is not the most promising sort in the northern Plains. The characteristic type of the spring-humid region is the Manchuria-Oderbrucker. The Manchuria and Oderbrucker varieties, while of different origin, are quite similar, and as neither is pure, they are usually indistinguishable in the field. The best-yielding type in the humid-winter area is the Tennessee Winter. None of these types is a pure variety, and in each case high yields are ob-

tained from their close geographical relatives when these are similar in type and source. These three types are shown in figure 7.

The Coast variety is a 6-rowed barley composed of many similar strains. Some of these are white, while others have an aleurone layer showing a blue tinge. All are large grained, of relatively low nitrogen content, and possess harsh awns which do not break off readily in thrashing. Owing to the fragments of awns which cling to many kernels, the grain does not run through the drill readily; and the drill therefore should be set at a somewhat heavier seeding rate than if Manchuria, for example, were to be used. The Coast barley probably came from North Africa, most likely through Spain. Wherever the Coast variety does well, other North African barleys do well. South American sorts, which doubtless were introduced into South America by Spain, yield well in the arid region. One such has been grown to a small extent under the name Peruvian.

As previously remarked, the Manchuria and Oderbrucker barleys of

the humid-spring region are very similar. Both are nodding 6-rowed forms having smaller kernels and more slender spikes and beards than the Coast barley. As in the Coast, they represent a type and not a pure variety. In each may be found white and blue-tinted strains. In field culture there is more blue in the Manchuria barley than in the Oderbrucker, and many of the selected strains of Oderbrucker are taller than the Manchuria. They have become so mixed that the original character of either is not easily determined. Selec-



FIG. 7.—Spikes from the predominating variety of barley in each of the three climatic regions: *a*, Coast (arid); *b*, Manchuria (humid spring); *c*, Tennessee Winter (humid winter).

tions of the Manchuria barley predominate in Minnesota and the Dakotas, while Oderbrucker selections are more commonly grown in Wisconsin. Although the Oderbrucker came from Germany, it probably has a common ancestry with the Manchuria. The only close relatives of the Oderbrucker and Manchuria barleys in farm culture are the Manshury and Scotch. The term Manshury is only a corruption of Manchuria, and the variety is not a separate sort. The Scotch was formerly quite common in the districts now growing Oderbrucker, to which it is very similar.

The Tennessee Winter barley is similar in appearance to the Manchuria. It has three or four more or less indistinguishable compan-



FIG. 8.—A field of Tennessee Winter barley.

ion varieties. The Maryland Winter and Texas Winter are probably identical with it. Prof. Mooers, of Tennessee, states that the Union Winter differs constantly from the Tennessee Winter in time of heading and ripening. A field of the Tennessee Winter variety is shown in figure 8.

VARIETAL AREAS.

In each of the three great regions may be found minor areas to which some particular variety or strain is especially adapted. The arid region presents more of these localities than either of the others, as would be expected from its diversity of climate. In the northern Plains, 2-rowed varieties succeed better than 6-rowed. In north-eastern Colorado, western Nebraska, western South Dakota, and western North Dakota, Hannchen has proved very dependable. This

is a narrow, nodding, 2-rowed barley. Many of its awns fall off about ripening time. In Montana on dry land the White Smyrna variety is coming into favor. It is also grown some in Wyoming and in the Great Basin. It is an extremely short-strawed 2-rowed variety, with an excessively large grain. It is often cut with difficulty with a binder, but is harvested readily with a header. The first impression is almost always adverse to this variety, but its large yields and attractive grain are steadily extending its culture. In the irrigated sections of Montana and even South Dakota, the Chevalier is a favorite variety. A considerable quantity of this sort is grown in the Gallatin Valley of Montana. It is similar to the Hannchen, but it matures much later and has a larger kernel. It is a favorite with the millers of pearled barley. In Idaho, under irrigation almost any variety yields well. On account of the ease of culture, the Coast type is the most common. The Chevalier, White Smyrna, Hannchen, and Trebi varieties are grown. The last is a very high-yielding sort just coming into cultivation.

At high altitudes and in places of very low rainfall coupled with high temperature, hooded varieties are grown to some extent. At high altitudes the Nepal, a 6-rowed, hooded, naked variety is frequently grown. It is quite early. In the southern Plains and parts of Oregon and Washington small areas of Horsford are grown. This is similar to the Nepal, but hulled instead of naked. In parts of South Dakota, where hot, dry weather comes on early and suddenly, early-maturing varieties are preferred. The Gatami has done well under



FIG. 9.—Spikes of five varieties of barley suited to areas in the arid region: *a*, Hannchen (Northern Plains and Great Basin); *b*, Smyrna (Montana and bordering areas); *c*, Chevalier (irrigated and subirrigated lands); *d*, Mariout (late seeding in California and the Great Basin); *e*, Nepal (mountain districts and for hay).

such extreme conditions. It is a 6-rowed, awned, black-hulled variety.

In the Great Basin a winter variety known variously as Winter Club, White Club, and Utah Winter is occasionally grown. It is a dense, 6-rowed, awned, hulled variety.

In the humid-spring region there are no sharply defined local areas.

In Michigan a winter barley has been developed which is reported as promising by the Michigan Agricultural Experiment Station. The northeastern part of the region is well adapted to the production of the Hanna variety, but it has not yielded as well as the Manchuria in New York.

In the humid-winter area the localities are classified on the presence or absence of barley rather than on the kinds of barley. The production is almost all in the mountain districts, although a small acreage is grown in the Piedmont area. The total production is small.

TABLE VI.—Description and adaptation of the varieties of barley most frequently found in field culture.

Classification, variety, and synonyms. ¹	Description.					Region adapted.	Area of special adaptation.
	Kernel rows.	Color. ²	Hulls.	Awns.	Spike.		
Three principal type varieties:							
Coast.....	6	White..	Hulled..	Awned..	Lax...	Arid.....	
Manchuria and Oderbrucker (<i>Manchuria</i>).....	6	...do....	...do....	...do....	...do....	Humid spring.	
Tennessee Winter.....	6	...do....	...do....	...do....	...do....	Humid winter	
Important minor varieties of less extensive distribution:							
Chevalier.....	2	...do....	...do....	...do....	...do....	Arid, irrigated	Northern irrigated lands.
Hannchen.....	2	...do....	...do....	...do....	...do....	Arid.....	Northern Plains and the West.
Mariout.....	6	...do....	...do....	...do....	Dense..	...do....	Late seeding in California and in the Great Basin.
Smyrna, white....	2	...do....	...do....	...do....	Lax...	...do....	Montana.
Trebi.....	6	...do....	...do....	...do....	...do....	Arid, irrigated	Great Basin.
Winter Club (<i>White Club</i> , <i>Utah Winter</i>).....	6	...do....	...do....	...do....	Dense..	Arid.....	Great Basin, fall seeding.
Less important minor varieties:							
Beldi.....	6	...do....	...do....	...do....	Lax...	...do....	About as Coast.
Gatami.....	6	Black..	...do....	...do....	...do....	...do....	Severe summer conditions, Northern Plains.
Hanna.....	2	White..	...do....	...do....	...do....	Arid, humid spring.	
Himalaya (<i>Guy Maile</i>).....	6	Blue...	Naked..	...do....	...do....	Arid.....	Northern Plains.
Horsford (<i>Success</i> , <i>Beardless</i>).....	6	White..	Hulled..	Hooded..	...do....	...do....	Southern Plains.
Nepal (<i>White Hulled</i> , <i>Beardless</i>).....	6	...do....	Naked..	...do....	...do....	Arid, humid spring.	Rocky Mountains.

¹ Synonyms are indicated by italic type in parentheses.

² In the hulled varieties the color refers to the glume only. Some of the white-hulled sorts have blue aleurone layers.

WHAT VARIETY TO GROW.

In general, it is best to grow one of the three standard commercial types, depending upon the region in which the grower lives. These types are the Coast, the Manchuria-Oderbrucker, and the Tennessee Winter. If the farm is located in a definite subdivision of one of these regions, varieties of such local adaptation should be used where seed is available. The five most conspicuous cases of special adaptation are Hannchen for the northern Great Plains, White Smyrna for the Montana dry lands, Chevalier for the Montana irrigated lands, Trebi for irrigated lands of the Great Basin, and Mariout for late seeding in California. Spikes of four of these are shown in figure 9. The State experiment stations should be consulted, as they are in a position to know the local variations which may determine the use of varieties. The character of the more important varieties may be seen in Table VI.

WHERE TO PROCURE SEED.

Seed should be obtained locally where possible. Seed of the three main types can be secured readily in any quantity through a large number of agencies. The Coast barley is handled by all grain dealers, elevators, and seedsmen of the West. The Manchuria and Oderbrucker are similarly handled in the northern Mississippi Valley. Many of the States have grain growers' associations which produce a better grade of seed, often of selected strains. These associations usually have a representative on the State experiment station staff from whom all information can be obtained. The Tennessee Winter barley is handled by southern seedsmen and by some grain dealers in the region of heaviest production.

The varieties of local adaptation are more difficult to secure. In most cases their culture is so recent that large lots of seed are not available. The Chevalier can be obtained in quantity in the Gallatin Valley of Montana, and considerable Hannchen has been distributed by the substations of South Dakota. There is a small production of Smyrna in Montana which so far has all been absorbed by local buyers of seed. The Trebi is not yet produced in quantity.

DISEASES.

Barley is not commonly subject to heavy infections of diseases. Its freedom from rust accounts in part for the practice of seeding it on lands where the planting of spring wheat is delayed to the point of danger. Barley is not immune to rust, and very late seedings are sometimes damaged. There is generally a small percentage of loose smut in barley and a varying percentage of stripe diseases. The stripe diseases, according to recent studies, appear to be of greater importance than was formerly thought to be the case. They may

eventually demand specific effort toward their prevention. At the present time only one barley disease is of clear-cut economic importance, for which recommendations of seed treatment are widely urged. This is the covered smut, which can be distinguished from the



FIG. 10.—The covered and loose smuts of barley: *A*, Covered smut, in which the kernel is replaced by masses of spores, which are broken apart and mixed with the grain in thrashing; *B*, loose smut, a form wherein the entire spikelet is replaced by a mass of spores, which upon maturity are scattered by the wind, leaving only the bare stems as evidence of the disease.

loose smut through the fact that the smut balls which displace the seed persist in the covered smut, but are broken up and dispersed by the wind before harvest in the loose smut. Formaldehyde is not effective in treating loose smut. These smuts are shown in figure 10. The importance of covered smut seems to vary inversely with the rainfall of the harvesting months. In the humid regions it is of only sporadic importance, the greater part of the fields escaping with unimportant losses. In the arid regions there is a gradual increase in infection, culminating in frequent, heavy losses in the Palouse district and parts of California.

Wherever the infection assumes any considerable importance, provision should be made for better conditions the following year. If clean seed can be secured, it should be used. Clean seed is to be preferred to treated seed. If it can not be secured, the seed should be treated with formaldehyde, 1 pound to 40 gallons of water.

The sprinkling method is not effective with the covered smut of barley. The method known as "soaking and skimming" is to be preferred. Place the solution in tubs or other containers and pour the grain in. Stir thoroughly. The stirring brings the smut balls to the surface, where they can be skimmed off. After skimming, remove the grain; pile and cover 2 to 5 hours with bags or canvas previously treated with formaldehyde. Make germination tests of treated seed to determine the amount of injury. Increase the amount of seed per acre to cover injury and swelling. Although the danger of seed injury in barley is much less than in wheat, some farmers prefer to treat only a seed plat for the next year's stock. When this method is used, the seed plat should be treated annually.

When the clean or treated seed is finally available for seeding, care should be taken to avoid reinfection. The drill should be disinfected with the formaldehyde solution and used sacks avoided. If the crop of the following year is clean and suitable for seed, care should be taken that the thrashing machine has not come directly from a field of smutty barley. If smutty barley was the last crop thrashed, the machine should be disinfected as far as possible. The same precaution should be taken with respect to the bins and sacks. Keep the disease out by sanitary measures when possible; when not possible, treat the seed.

SUMMARY.

The United States may be divided into three barley regions, which differ in economic, cultural, and varietal aspects—the arid, or western; the humid-spring, or northeastern; and the humid-winter, or southeastern.

In the arid region, the Great Plains, the Great Basin, and the Pacific coast are well-defined subdivisions.

Barley is most profitable as a primary crop, but is a valuable secondary crop, as when it is used for late seeding in the spring-wheat region or to clean weedy fields.

The best barley lands are well-drained soils that are not sandy. Heavy loams are the best. It should not be seeded on poorly drained or light sandy lands.

Barley is a cool-weather plant. The best conditions of growth are found in early spring. In the humid regions, south of those sections where the summers are cool, early seeding is of vital importance.

Barnyard manures in the humid-spring region should be applied to the previous crop, as they induce lodging when applied to barley. The use of commercial fertilizers on barley is at present limited largely to the Eastern and Southern States.

Good seed of a good variety, well matured, well cleaned, and free from weed seeds and diseases, is an insurance that the crop starts without a handicap. A good seed bed will promote the initial growth.

Fall plowing in the humid-spring region, disked corn ground in the Great Plains, and summer fallow in regions west of the Rocky Mountains are the best methods of preparation.

Early seeding is necessary to secure maximum returns. In the northern Plains, the loss from seeding delayed beyond April 25 is more than 1 per cent a day.

In the humid sections, 2 bushels are usually seeded. The rate decreases with the decrease in rainfall. In the driest sections, 3 or 4 pecks is sufficient.

The depth of seeding varies from 1½ inches in the humid regions to 2½ or 3 inches in the Great Basin.

The best method of seeding is with the grain drill.

Barley should be mature when harvested, but should not be allowed to stand until the losses from shattering become important. The varieties of the humid region and Great Plains shatter more than those of the arid regions.

The best method of harvesting is with the grain binder. The combined harvester is cheaper to operate, but the losses are greater.

Grain must be shocked and stacked, so as to suffer the least weather damage possible. Care should be taken in thrashing that few kernels are broken. Close thrashing decreases the market price of malting barley.

Barley is manufactured into malt, pearled barley, breakfast food, and flour. The malting trade demands a grain that is clean, plump, free from weather, bin, or thrashing damage, and of high viability.

Barley is an important reserve flour grain. From 15 to 80 per cent of barley flour can be mixed with wheat flour, depending upon the type of bread to be baked.

On account of its high acre yield barley should be more widely grown for stock feed. Through the Northern and Western States, it should replace oats to a considerable extent. It may be fed whole, but is better rolled or coarse ground.

In present practice each of the three regions has a predominant type that succeeds well throughout that region. These are the Coast in the arid region, the Manchuria and Oderbrucker in the humid-spring region, and the Tennessee Winter in the humid-winter region. Of the less widely grown varieties, the Hannchen does well almost anywhere, but seems particularly adapted to the middle Plains. In Montana, the White Smyrna is superior, and in the southern Plains, the Horsford. In the Great Basin, in addition to the Coast, the Mariout and Hannchen are promising. In California, besides the

Coast, the Mariout is useful for late seeding. Under irrigation the Trebi, in the Great Basin, and the Chevalier, in Montana, are especially well adapted.

The covered smut is an important source of losses in the dry regions, especially in eastern Washington and Oregon.

Disease-free seed should be obtained, if possible. If this is not possible the seed should be treated.



**CULTIVATION AND
UTILIZATION OF BARLEY**

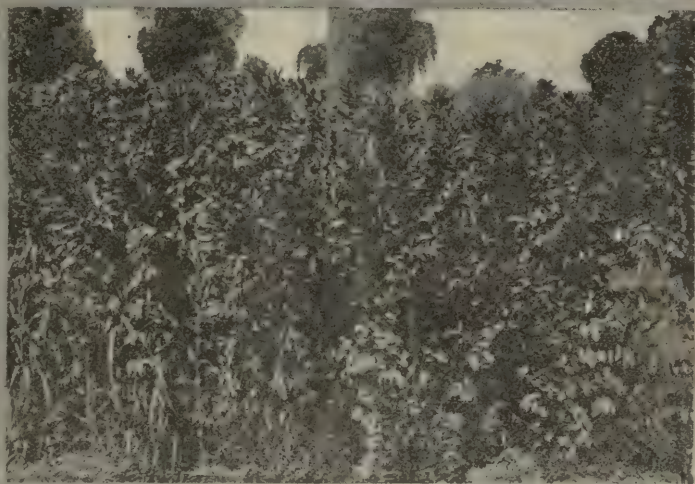
FARMERS' BULLETIN 264

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HORSE BEANS

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FARMERS BULLETIN, 969

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
Wm. A. TAYLOR, chief

Washington, D.C.

May 1918

HORSE BEANS have been grown in the Old World since very ancient times and are valuable as forage, as green manure, and as a vegetable.

Heavy loams or clay-loam soils are best suited for horse beans, but the crop is not very exacting as to soil requirements.

All horse-bean varieties are winter-growing annuals and require cool weather for their best development. The hardier varieties will stand with little injury a temperature of 15° F. above zero. Some of the tenderer varieties, however, will stand but little freezing. Where severe winters prevail, horse beans must be sown in early spring. In regions having mild winter conditions they should be sown in the fall. Plantings should be in rows 24 to 30 inches apart.

Planters used for Lima beans and the smaller seeded varieties of field beans can be used for horse beans. Horse beans planted on land for the first time require inoculation.

Only sufficient cultivation to keep down weeds need be given.

Horse beans should be cut for seed as soon as the lower pods are mature and the upper ones fully developed. They must be handled as rapidly as possible, as the seed shatters easily.

Under favorable conditions the seed yields are heavy. An average yield is about 1½ tons per acre.

The seed of horse beans retains its vitality for a long period. In germination tests, seed 4 years old has shown only slight, if any, deterioration.

HORSE BEANS.

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HORSE-bean varieties are numerous and it seems probable that their number, even in the earliest days of agricultural history, was large. The date of the introduction of the horse bean into America is unknown, but the crop has been grown to a limited extent for a number of years in most of the countries of North,

Central, and South America. It succeeds best in the regions near the sea, and the Maritime Provinces of Canada and the Pacific Coast States contain practically the entire acreage in North America, and similarly situated sections in China, Japan, Java, and Madagascar have proved favorable locations for the crop.

The high yield and quality of this crop, as demonstrated in the experimental and commercial fields on the Pacific coast, together with its high feeding value, indicate that it can be used to advantage much more extensively in this country than is the case at the present time.

DESCRIPTION OF THE HORSE BEAN.

The plants of horse beans live only one season. They are erect, with one or more large unbranched stems which attain a height of 2 to 6 feet. The leaves are abruptly pinnate and usually with six leaflets, which are large, oval, and without special markings. Large white flowers with dark-purple markings are borne on short pedicels in clusters of one to five in the axils of the leaves. (Fig. 1.) From one to four pods develop from each flower cluster. The varieties bearing large pods usually have one pod in a place, but the smaller podded varieties generally have two or three. The size and color of the seed vary with the varieties. They may be black, purple black, green, or various shades of brown, the latter being the color

of the more common varieties. The size of the seed varies from about 1 inch in length in the large flat-seeded varieties to one-fourth inch in the varieties having small, plump, or nearly round seeds. (Fig. 2.)

USES.

The large flat-seeded varieties of the horse bean are used quite extensively as a vegetable either in a green or dry state, while the



FIG. 1.—Horse beans in flower. The flowers are white with purple markings. One to four pods develop from each flower cluster.

smaller seeded varieties are seldom used as a vegetable. As a green vegetable the large varieties are grown as a home-garden product or for canning purposes. When used in these ways, the beans are allowed to become full grown, but are picked before they become hard. When used as a vegetable in the dry state, they are prepared in the same way as any of the common beans.

The large-seeded varieties have been grown, especially in European countries, as a stock feed, though the small-seeded varieties are most commonly used for this purpose. The feeding value of horse beans is high and is considered in some cases to be superior to field peas or other leguminous crops. This high feeding value together with the



FIG. 2.—Seeds and pods of large, intermediate, and small seeded varieties of horse beans. The large flat-seeded varieties are used as a vegetable. (Two-thirds natural size.)

fact that the yield of seed is very large makes it a crop that often can be grown for stock feed when other leguminous crops would be prohibited on account of the cost of production.

In the United States practically the only use that has been made of horse beans is for vegetable purposes; and while they have been grown more or less for use in a green state, large commercial plant-

ings have been made for the production of matured beans for use as a dry vegetable. However, some use has been made of them for stock-feeding purposes, and in some of the bean-growing sections of California they have been harvested by "hogging down," with very satisfactory results. The horse bean is of little value as hay, and stock do not seem to care for the stems and leaves in the green state; but in combination with corn and sunflowers it has been used quite successfully as silage.

Various varieties of horse beans have been tested in the United States for green-manuring purposes in comparison with other legumes. Very satisfactory results have been obtained in this work in the citrus districts of California, and while the crop has not been used on an extensive scale as a green manure this has been largely due to the high cost of seed. The only seed available in the commercial markets in the United States is that of the large-seeded varieties, and while the price per pound is comparatively low the quantity necessary for seeding, on account of the large size of the seed, makes it an expensive crop to plant. The introduction and use of small-seeded varieties would overcome this difficulty, and it seems likely that this will be accomplished in the near future.

SOIL REQUIREMENTS.

Horse beans are not very exacting as to soil requirements, but do best on well-drained heavy loam or clay-loam soil. Good results have been obtained, however, both on quite heavy and on sandy soils. While the type of soil makes some difference to the crop, soil moisture perhaps is more important. With sufficient moisture present, any fairly fertile soil will produce a good crop of horse beans.

CLIMATIC REQUIREMENTS.

Horse beans require practically the same climatic conditions as common vetch. The hardier varieties stand a winter temperature of 15° F. above zero without serious injury. Some of the tenderer varieties, however, will stand but little frost. (Fig. 3.) Horse beans are not adapted to intense heat or even moderately warm temperatures, and it is essential for their successful development that they have a growing season that has but little or no excessive heat. Aside from being unfavorable to the normal development of the plant, high temperatures favor the development of certain fungous diseases, which often do serious damage.

TIME OF SEEDING.

In localities having mild winter conditions, such as prevail in the Southern and Pacific Coast States, horse beans of most varieties can be sown in the fall and will go through the winter in perfect condition.

In these States seeding can be done in September, October, or November, the exact time depending quite largely upon the soil moisture available in those months.

In northern localities, or at high elevations farther south where severe winter conditions prevail, planting should be done as early in



FIG. 3.—Outline map of the United States, the shaded portions showing the areas where the climatic conditions are favorable to the fall seeding of horse beans.

the spring as the ground can be worked. The seeding time for the earliest ordinary spring crops is the best time for seeding horse beans under such conditions.

METHOD OF SEEDING.

Horse beans can be satisfactorily planted with planters used for field beans. The large-seeded varieties can be sown with planters used for Lima beans, while the smaller seeded varieties can be sown with those used for the smaller seeded kidney beans. Some of the smaller seeded varieties can be planted with a common corn planter, but the larger seeded varieties can not be handled with such implements. In California, where most of the horse beans in the United States are grown, much of the planting is done by hand. The field is plowed shallow at seeding time and the seed dropped in every second or third furrow. The usual method is to make the rows about 30 inches apart and to drop the seeds 6 inches apart in the rows. Rows 24 inches apart, or even closer, will give good results under favorable conditions, but usually wider planting is preferable.

INOCULATION.

As is the case with most, if not all, legumes, the inoculation of horse beans is essential for the best results. In the better loam soils of California artificial inoculation does not seem to be essential, as the necessary bacteria apparently are present in the soil. On less favorable soils and in places where horse beans have not been grown successfully, inoculation is desirable, and in some cases perhaps essential. In western Oregon and western Washington inoculation has been found desirable, and it is advised in all parts of the United States where horse beans are grown for the first time.

The easiest method of inoculation, and one perhaps as effective as any other, is to mix a small quantity of inoculated soil with the seed at the time of seeding. The quantity of soil used need be only enough to give a mere dusting to the seed, which will in no way interfere with seeding operations. Inoculation can be obtained also by scattering inoculated soil at the rate of 250 to 500 pounds per acre over the field immediately preceding planting. When soil is used in this manner a harrowing should be given the field immediately following the application of the inoculated soil, so as to incorporate it with the soil of the field and furnish favorable conditions for the protection and growth of the bacteria. When soil for inoculation is not available, pure cultures can be used.

CULTIVATION.

Horse beans should be given thorough cultivation throughout their growing period. When planted in 24-inch rows or closer, special machinery is necessary for cultivation. When plantings are made in 30-inch rows, however, a number of the ordinary cultivators can be adjusted so they can be used. Thorough cultivation is necessary in order to keep the soil in good physical condition and to keep down weed growth and thus make conditions more favorable both for growing and harvesting the crop. The number of cultivations that should be given will depend upon local conditions, but usually cultivation sufficient to prevent the growth of weeds is all that is necessary and ordinarily this involves as much labor as can be afforded.

HARVESTING FOR SEED.

The time of harvesting horse beans for seed depends somewhat upon whether the work is to be done by hand or by machinery. If the crop is to be cut by hand the time can be delayed a little longer than if it is to be cut by machinery. In either case, however, the plants should not be cut until the lower pods are matured and the upper ones fully developed. If the time of harvesting is delayed until the upper pods are ripe a large quantity of seed will be lost by shattering.

While an ordinary mowing machine can be used in cutting horse beans, the drop-rake reaper is a much more satisfactory implement, and with its use but little seed is lost by shattering if due precautions are taken. (Fig. 4.) When a mowing machine is used, it is necessary to rake the crop by hand, using ordinary pitchforks, which entails a great deal of labor. If an ordinary horserake is used, a large quantity

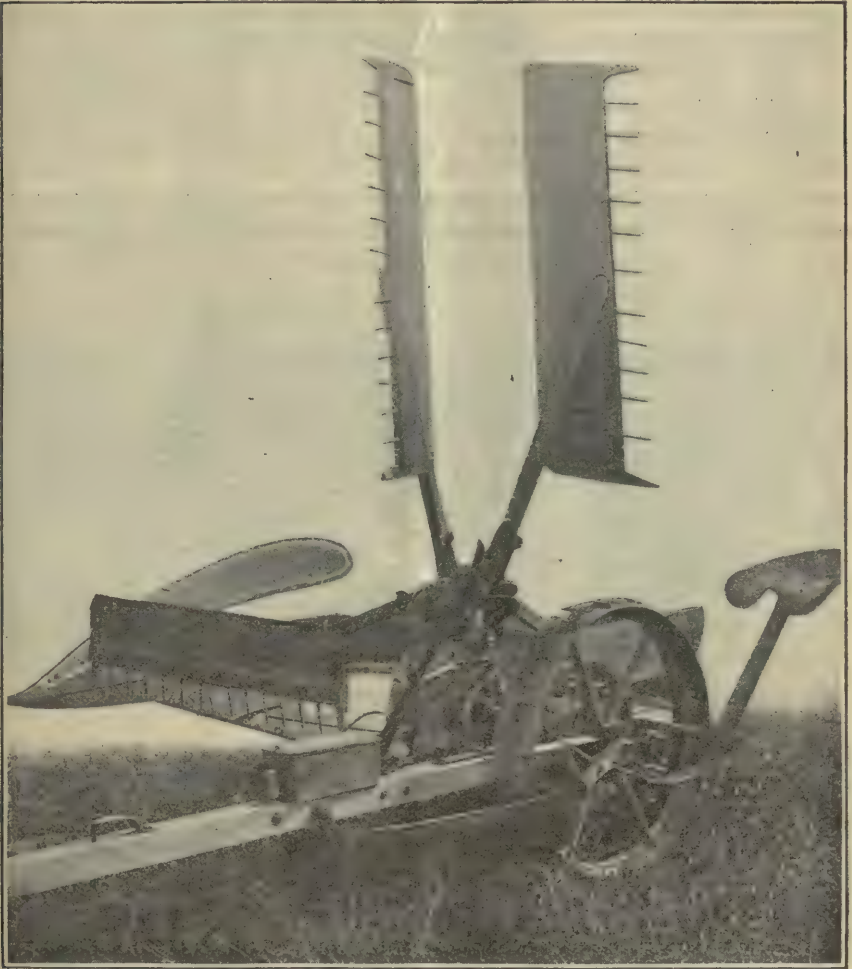


FIG. 4.—Drop-rake reaper used in harvesting horse beans. The plants should not be cut until the lower pods are mature and the upper ones fully developed.

of seed is lost by shattering. While in using a drop-rake reaper under favorable conditions very little seed is lost, it is essential in order to reduce this loss to a minimum that the crop be handled with but little delay.

When possible a cloudy day should be selected for cutting the crop, and if only bright, warm weather prevails during the harvesting

season the cutting should be done at night. If the cutting is done between midnight and morning and the shocking done immediately following daylight, little seed will be lost even during dry weather. The shocking should be done by hand, using an ordinary pitchfork. A fairly good sized shock is desirable, provided the material does not have to be carried too far. (Fig. 5.)

The thrashing of the large-seeded varieties of horse beans is somewhat difficult. However, fairly satisfactory results can be secured by using a common bean thrasher and making special adjustments of the cylinder. The small-seeded varieties can be thrashed without difficulty. In sections where thrashers are not available or when only a small acreage is grown, the crop can be thrashed by the old-time



FIG. 5.—Horse beans cut with a drop-rake reaper and shocked by hand, using pitchforks, Gilroy, Cal.
A fairly good-sized shock is desirable.

process of rolling. For this purpose a heavy stone roller is most satisfactory, and this method is used to some extent in California. After thrashing with the roller, the seed can be cleaned with ordinary fanning mills or by operating on windy days, when most of the dust and lighter material can be separated by merely throwing the seed into the air and catching it on a large canvas.

But little experimental work has been done to determine definitely the yields of seed of the various varieties of horse beans. In the limited experiments in California and Oregon large yields have been secured. Large yields have also been obtained from commercial plantings. In the most favorable localities and in favorable seasons a yield of 2 tons of seed per acre has been reported. Under average conditions a yield of $1\frac{1}{2}$ tons per acre perhaps can be expected.

LONGEVITY OF SEED.

Horse-bean seed retains its vitality for a number of years. Whether varieties differ with regard to the longevity of seed has not been determined. Germination tests of seed 4 years old of a number of varieties grown at Chico, Cal., showed little or no deterioration. From this it would appear that the life of all varieties of horse beans is quite long. While there is no hard seed in any of the varieties so far as known and perfect germination is secured with new seed, there seems to be no disadvantage in using older seed for planting purposes, and in some respects the older seed is decidedly preferable. Seed 1 or more years old will contain no live larvæ or adults of the weevil,¹ and by using such seed the weevil will not be introduced into fields or sections in which it is not already present.

FUNGOUS DISEASES.

There is but one fungus that severely attacks the horse bean. This is a leaf spot² that develops in the spring and does great damage to both leaves and pods. In the warm, humid sections of the eastern and southern United States horse beans are practically destroyed in some seasons by this disease. In the Western States, where more favorable conditions prevail, there is little damage done except to the more susceptible varieties. Experimental work has shown considerable difference in varieties with regard to their resistance to this fungus, and it seems probable that by selecting the more resistant strains the successful growing of this crop can be extended to regions where it is now unprofitable.

INSECT ENEMIES.

The most important insect enemy of the horse bean is the weevil.³ In recent years in various sections of California this insect has done serious damage.

The adult insect lives through the winter in the seed, emerging during the period of blossoming of the plants. The female deposits her eggs in the flower of the developing pods, where they hatch and the young larvæ penetrate the young seed. As the seed matures there is little indication of the presence of this insect, but on examination slight depressions and discolorations will be noted on the matured pod and seed. After harvesting, most of the larvæ develop

¹ *Larix rufimana*.

² *Ascochyta* sp.

³ (*Bruchus*) *Larix rufimana* Boheman. Detailed information regarding this weevil is given in Bulletin 96, part 5, of the Bureau of Entomology, United States Department of Agriculture, which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 5 cents. Remedies for this and other bean and pea weevils are given in Farmers' Bulletin 983. This may be obtained free from the Division of Publications, United States Department of Agriculture.

rapidly, and within two or three months' time many will have reached the adult stage and will have emerged from the seed. However, many of the adults do not emerge until the following spring, when they become the source of infestation of the new crop.

This insect can be killed in the larval stage by heating the seed to 140° F., which will not injure germination, or by fumigating for 48 hours with carbon bisulphid, using 2 or 3 pounds to 1,000 cubic feet of air space. As the entire life period of this insect is but one year, holding seed until the second year will insure its being free from live weevils.

When horse beans are to be used as a vegetable, the damage done by these weevils is very serious. When the crop is to be used for stock feed it is not so objectionable, but even in this case it occasions considerable loss.

Horse beans are often attacked by aphids, or plant lice, which occasionally do serious damage. The aphids feed on the growing plant, sucking or sapping its juices, thus retarding the development of the crop and greatly reducing seed setting. Nicotine sulphate and other remedies advised for the melon aphid¹ are recommended.

¹ See Farmers' Bulletin 914, "The Control of the Melon Aphid," which may be obtained free from the Division of Publications, United States Department of Agriculture.

“YOU WILL REALIZE, as I think statesmen on both sides of the water realize, that the culminating crisis of the struggle has come and that the achievements of this year on the one side or the other must determine the issue. It has turned out that the forces that fight for freedom, the freedom of men, all over the world as well as our own, depend upon us in an extraordinary and unexpected degree for sustenance, for the supply of the materials by which men are to live and to fight, and it will be our glory when the war is over that we have supplied those materials and supplied them abundantly, and it will be all the more glory because in supplying them we have made our supreme effort and sacrifice.”—*From President Wilson's Message to Farmers in Conference at Urbana, Ill., January 31, 1918.*

Sweet Potato Storage

H.C. Thompson

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Farmers' Bulletin 970

United States Department of Agriculture



Contribution from
the Bureau of Plant Industry
Wm.A.Taylor, Chief

Washington, D.C.

May, 1918



THE PROPER storage of sweet potatoes is one of the most important food-conservation measures that can be put into effect in the Southern States. No perishable product produced in the South is of as great importance as the sweet potato, and none is so poorly handled.

This bulletin describes in considerable detail the types of storage houses that have proved successful and the proper method of handling sweet potatoes from harvesting to marketing.

For those growers who are not able to build storage houses, directions are given for saving the sweet-potato crop by using outdoor cellars and banks.

SWEET-POTATO STORAGE.¹

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IMPORTANCE OF THE SWEET-POTATO CROP.

THE SWEET POTATO is becoming each year of greater importance as a money crop in the South. Its value in 1916 was \$60,141,000, an increase of 74.6 per cent over the figures of the census of 1910. The acreage, production, and value of the crop grown in the important sweet-potato producing States in 1916 are shown in Table I.

TABLE I.—*Acreage, production, and value of sweet potatoes grown in important States and in the United States in 1916.*

State.	Acreage.	Production.	Value.	Yield per acre.	Value per acre.
		<i>Bushels.</i>		<i>Bushels.</i>	
New Jersey.....	23,000	2,300,000	\$2,760,000	100	\$120.00
Delaware.....	5,000	625,000	506,900	125	101.25
Maryland.....	9,000	1,134,000	998,000	126	110.88
Virginia.....	39,000	5,070,000	4,563,000	130	117.00
North Carolina.....	87,000	9,309,000	6,982,000	107	80.25
South Carolina.....	66,000	5,676,000	4,825,000	86	73.10
Georgia.....	94,000	7,520,000	6,091,000	80	64.80
Florida.....	25,000	2,500,000	2,150,000	100	86.00
Illinois.....	8,000	720,000	900,000	90	112.50
Missouri.....	7,000	490,000	735,000	70	105.00
Kansas.....	4,000	368,000	552,000	92	138.00
Kentucky.....	10,000	900,000	900,000	90	90.00
Tennessee.....	27,000	2,700,000	2,349,000	100	87.00
Alabama.....	85,000	6,290,000	4,655,000	74	54.76
Mississippi.....	77,000	6,314,000	4,230,000	82	54.94
Louisiana.....	64,000	5,760,000	3,802,000	90	59.40
Texas.....	80,000	7,120,000	6,408,000	89	80.10
Oklahoma.....	13,000	962,000	1,299,000	74	99.90
Arkansas.....	35,000	3,185,000	866,000	91	81.90
California.....	6,000	960,000	960,000	160	160.00
Total for the United States.....	774,000	70,955,000	60,141,000	91.7	77.70

The States showing the lowest value per acre as a rule have the lowest yield and also receive the lowest price per bushel. In general, those States storing the largest percentage of the sweet-potato crop

¹ The plans and lists of materials given in this bulletin were prepared by the Division of Rural Engineering of the Office of Public Roads and Rural Engineering, United States Department of Agriculture.

have the highest value per acre and receive the highest price per bushel. This is due largely to the fact that where storage facilities are available the potatoes are not forced on the market at digging time. Sweet potatoes stored in up-to-date storage houses bring a higher price on the market than those stored in banks and pits. By the adoption of the better methods of storing and marketing sweet potatoes, their value could be greatly increased without increasing the acreage or production. This is especially true in the South, where they are either rushed on the market at digging time, when the price is low, or stored in outdoor pits or banks, where a large portion of them decay. Very few of the potatoes stored in pits or banks ever reach the market, for from 25 to 50 per cent spoil, while those that remain sound are not of good quality.

Even if the pit or bank method of storage were satisfactory in other respects, it is not economical. Too much labor and expense are required to make these banks every year and to get the potatoes out of them when wanted for market. Sweet potatoes can be marketed more economically and to much better advantage from storage houses. It is not advisable to open a bank when the soil is wet or the weather cold, as these conditions injure the potatoes and cause them to decay. Outdoor pits and banks can not be depended on. In some years a very small number spoil in banks, while in other years practically the whole crop is lost. The only safe and practicable method of storing sweet potatoes is in a storage house, for then they can be taken out at any time without subjecting them to unfavorable conditions.

ESSENTIALS OF GOOD STORAGE.

To keep sweet potatoes in good condition they must be (1) well matured before digging, (2) carefully handled, (3) well dried or cured after being put in the house, and (4) kept at a uniform temperature after they are cured.

The grower can judge when his sweet potatoes are ripe by breaking or cutting one of them and leaving it exposed to the air for a few minutes. The cut or broken surface dries if it is mature, but the surface remains moist if it is not ready to be dug. However, in regions where early frosts occur the potatoes should be dug about the time the first hard frost is expected, regardless of their stage of maturity.

The second essential, careful handling, should be observed in digging, gathering, hauling, and unloading. Sweet potatoes should be sorted in the field and gathered in padded baskets or boxes to prevent bruising or breaking the skin. The baskets or boxes should be loaded on the wagon, hauled to the storage house, and the potatoes carefully placed in the bins. When they are to be hauled very far, a wagon with bolster springs should be used. Sweet potatoes should

never be thrown from one row to another, loaded loosely into a wagon body, or hauled in bags, because either of these practices will bruise them and afford an opportunity for disease to enter.

The third and fourth essentials thorough drying and a uniform temperature, may be secured in a storage house where artificial heat can be supplied. The house must be constructed in such a way that it can be thoroughly ventilated when necessary and yet be made nearly air tight in cold weather. These requirements are provided in the types of houses described in this bulletin.

It is good economy to build a substantial sweet-potato storage house, because it will last longer and require less attention than a cheap, poorly constructed one. It would be possible to keep the potatoes in a cheaper and less carefully constructed house, but the attention required and the additional fuel used would soon exceed the cost of the extra labor and material necessary for building the better one. The chances of loss are much greater in a poorly built than in a well-built house.

CONSTRUCTION OF SWEET-POTATO STORAGE HOUSES.

Sweet-potato storage houses may be built of wood, brick, hollow tile, cement, or stone. Wooden houses are preferable, because they are cheaper and easier to keep dry than the other types. It is difficult to keep moisture from collecting on the walls of a cement, stone, or brick house. Where such houses are built for sweet-potato storage they should be lined with lumber, so as to keep the air in the house from coming in contact with the masonry walls. It is best to build sweet-potato storage houses on foundations that allow a circulation of air under them. The "dugout," or house built partly under ground, is not satisfactory for storing sweet potatoes in the South, because it is practically impossible to keep this type of house dry, and moisture in the storage house will cause the crop to rot.

The foundation of the storage house may be in the form of pillars or solid walls and should be of such a height that the floor is about on the level of the bottom of the wagon bed, while the footings should be carried below the frost line or to solid ground. Girders 6 by 10 or 8 by 8 inches in size are usually placed on the pillars.

Where cement, brick, or stone foundation walls are built, they should extend 18 to 20 inches above the ground level; and plates 2 to 3 inches thick and 8 to 10 inches wide should be placed on the wall. In using walls for the foundation it is necessary to provide means for ventilation under the house. This can be done by placing small windows in the foundation every 10 to 12 feet. Even where solid outside foundation walls are used it is advisable to use pillars for the center supports, as shown in figures 1, 2, and 3. The rows of pillars should be not farther apart than 8 to 10 feet.

The principles of constructing storage houses of various sizes are very much the same; therefore, only one, the 12 by 16 foot house, will be described.

For this small storage house, having a capacity of 400 to 500 bushels, build three rows of pillars, one row under each side and one under the center of the house. Girders 6 by 10 inches in size are placed on the pillars and on these 2 by 8 inch joists, spaced 12 inches apart from center to center. The walls of the storage house are made by setting 2 by 4 inch studs on the girders every 2 feet and

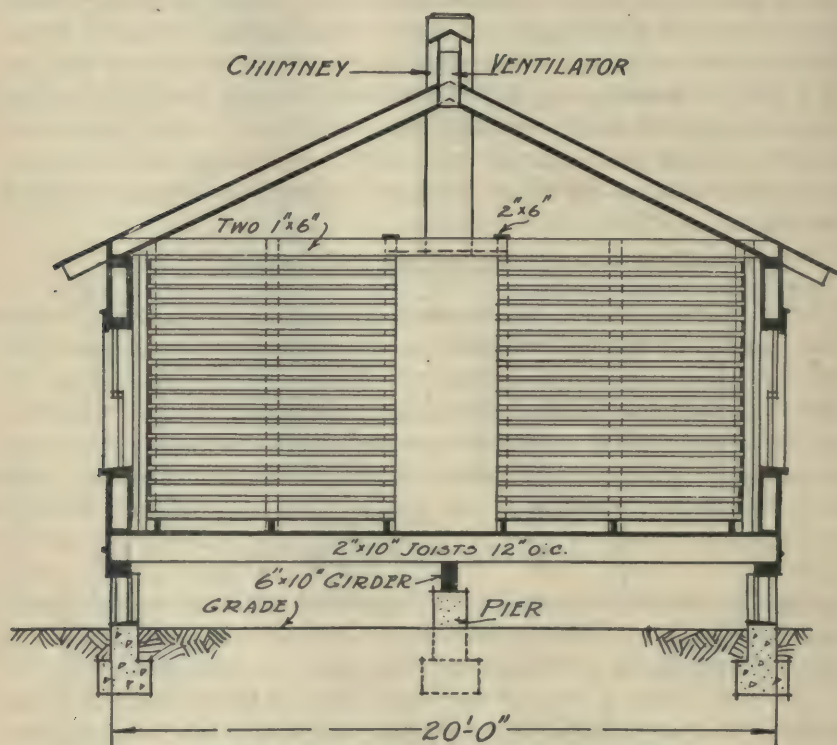


FIG. 1.—Cross section of a 20 by 40 foot sweet-potato storage house.

nailing them to the sleepers. On the outside of the studs 1 by 6 inch boards are nailed diagonally to brace the wall; over these a layer of heavy building paper is tacked and matched siding then put on. A layer of 1 by 6 inch boards is nailed on the inside of the studding, then a layer of building paper, and over this matched boards. In the lower South, the first layer of boards on the inside of the studding may be omitted so far as the control of temperature is concerned, but in regions of high humidity (near the seacoast) it is deemed advisable to use four layers of boards, two on the inside and two on the outside of the frame, as suggested above. The tighter the walls,

the less difficulty will be encountered in controlling both temperature and moisture. Two 2 by 4 inch pieces should be placed on top of the studding for eave plates, to which the rafters are nailed, as shown in figure 4. The floor is made by laying 1 by 6 inch sheathing over the joists, then a layer of heavy building paper and over this 1 by 4 inch tongue-and-groove flooring. The building may be covered with shingles, roofing paper, galvanized iron, or any other kind of roofing material; but galvanized iron is to be preferred, because it is durable and lessens danger from fire. Use 2 by 4 inch scantling for rafters and make the roof tight to keep out the cold. The rafters should be

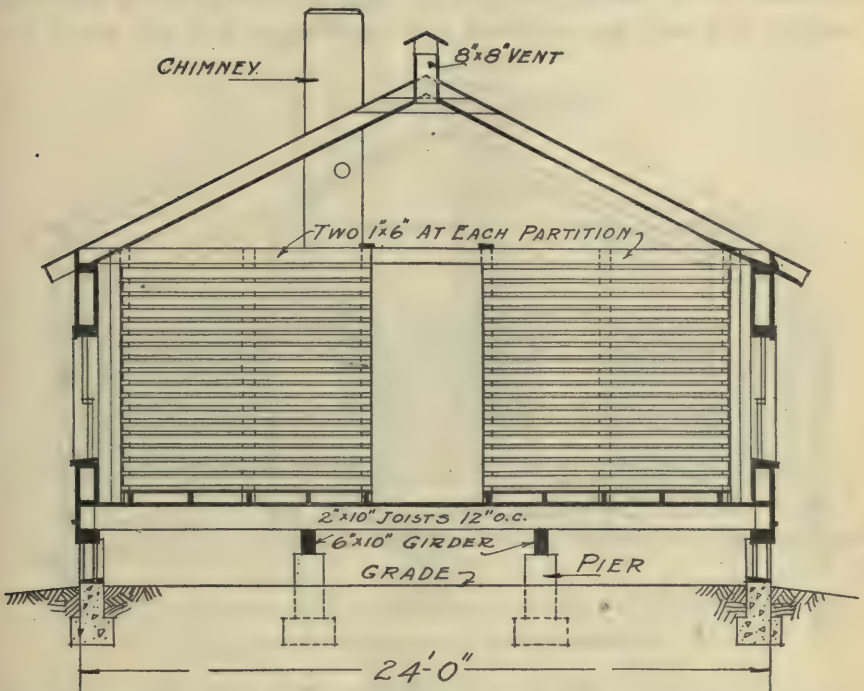


FIG. 2.—Cross section of a 24 by 60 foot sweet-potato storage house.

cut to fit over the plate at the lower end and to fit snugly against the ridgepole at the upper end. On the outside of the rafters put a layer of 1 by 6 inch sheathing, then a layer of building paper, then another layer of 1 by 6 inch sheathing, and over this the roofing material. On the inside of the rafters nail a layer of 1 by 6 inch sheathing, then a layer of heavy building paper, and over this a layer of tongue-and-groove ceiling. If desired, joists may be placed across the building on top of the eave plates, and the sheathing, paper, and tongue-and-groove material nailed to the under side of them instead of to the rafters. These joists, if securely nailed to the plate, will serve for tying the sides of the building together, as well as for carrying

the insulated ceiling. In a large house this method of ceiling is very satisfactory, as it gives loft space above the storage room and requires less ceiling material.

The sides of the building should be tied together, to prevent spreading. This can be done by nailing 2 by 4 inch pieces to the plates or to the lower ends of the rafters. It would be an advantage to have these pieces over the bin supports.

The space between the walls should be left open, because any material used to keep out the cold will absorb moisture. Many storage houses have been built with sawdust, shavings, or similar material between the walls, but this practice should never be followed. Sawdust will take up moisture and when once wet will never dry

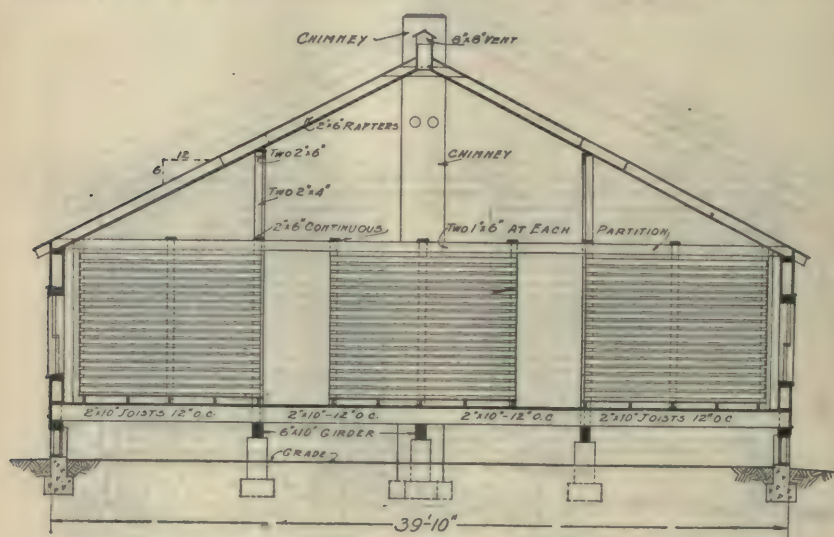


FIG. 3.—Cross section of a 40 by 100 foot sweet-potato storage house.

out. This moisture will keep the house damp and cause the walls to rot. The air space is a good insulator if the walls are made tight, and they will be tight if the plans given in this bulletin are followed.

Thorough ventilation is necessary in a storage house. This is provided by means of windows, doors, and ventilators in the floor and through the roof, as shown in figures 1 to 3, 5, and 7 to 10. The openings in the floor around the stove prevent overheating the potatoes near the stove. The bottom of the windows should be within 18 inches or 2 feet of the floor. The windows and doors must be made so as to close tightly to keep out the cold. A good plan is to make the doors and windows like those shown in the title-page illustration. All windows should be made to open from the outside, as the bins will interfere with opening them from the inside. Where

glass windows are used, outside shutters are put on, as shown in figure 6, and these should be well padded. Some of the windows should be made of glass, so as to admit light without letting in cold air, as it is necessary to have light when working in the house and in cold weather the house should not be kept open. All of the openings must be made so they can be closed quickly and tightly whenever necessary. The ventilators in the roof should extend through the

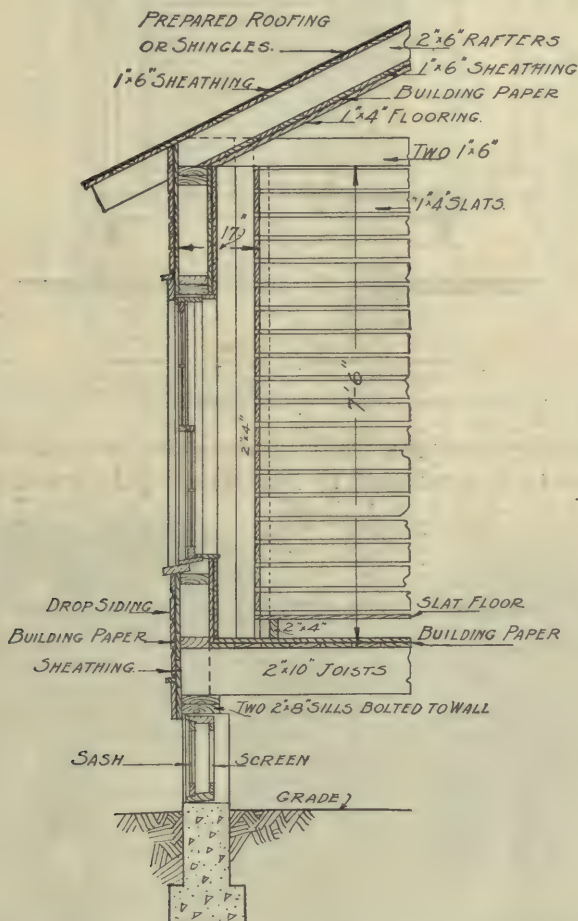


FIG. 4.—Details of construction of sweet-potato houses of the types shown in figures 1 to 3, 5, and 7 to 9.

ceiling, so as to carry out the warm air as it rises. Ventilators 8 by 8 or 10 by 10 inches, made of wood, are very satisfactory. These should be provided with a roof to keep out rain and at the bottom end with a tight-fitting shutter, which can be closed in cold weather. The ventilators in the floor may be holes 12 by 12 inches, but they should be provided with wire-netting screens and tight-fitting covers, that they may be closed when necessary.

The arrangement of the interior of the house depends upon the methods of storage used. Some growers store the potatoes in boxes,

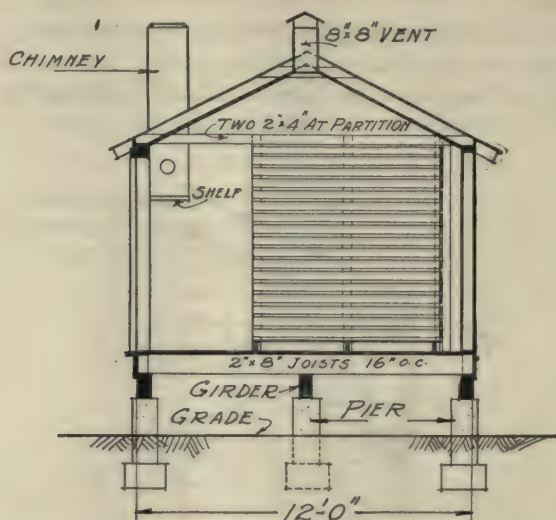


FIG. 5.—Cross section of a small sweet-potato storage house (12 by 16 feet).

crates, baskets, or hampers, while others store in bins. The smaller containers are to be preferred to bins where it is practicable to use



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FIG. 6.—A small sweet-potato storage house (12 by 24 feet) built with cheap lumber and covered with roofing paper. This house has been used for several years and has given entire satisfaction.

them, because they eliminate considerable handling and reduce the amount of decay. Many growers store in the hampers that are to

be used for marketing the potatoes. This is a satisfactory plan, as it requires no outlay of money for storage receptacles, and the packages for shipping must be provided in any event if the crop is to be marketed. Some growers have bushel boxes made for the special

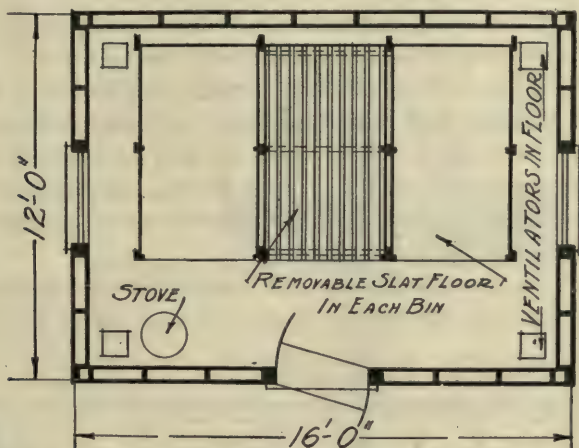


FIG. 7.—Floor plan of a small sweet-potato storage house (12 by 16 feet) suitable for a farmer who has 300 to 500 bushels of sweet potatoes to store.

purpose of storing sweet potatoes, while others employ various types of used crates. In using any type of package it is necessary to provide means for ventilation. A false slatted floor is often made by nailing 1 by 4 or 1 by 6 inch boards to 2 by 4 inch scantling. An inch

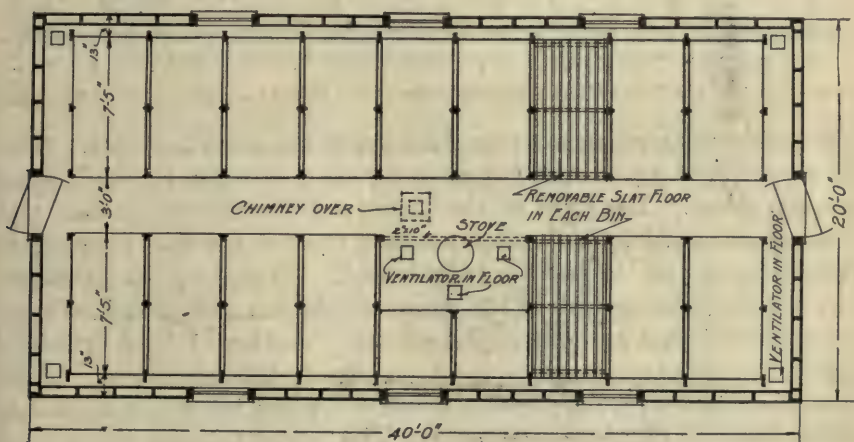


FIG. 8.—Floor plan of a 20 by 40 foot sweet-potato storage house having a capacity of 2,000 to 2,500 bushels.

space should be left between the boards to allow the circulation of air. A little space should be left between the stacks of boxes, baskets, crates, or hampers. Where these smaller containers are used, especially when the same package is employed for shipping the crop,

it is much easier to disinfect the storage house by spraying than when bins are used. Another advantage in using them is that when decay sets in it usually spreads only to the potatoes in the single package, whereas in the bin it might spread throughout the entire pile.

If bins are to be used, the interior of the storage house should be arranged for convenience in handling the sweet potatoes. A passageway about $3\frac{1}{2}$ to 4 feet in width is usually left between the rows of bins, or between the wall and the bins in a house with only one row of bins. Sufficient open space must be left to allow access to the ventilators in the corners of the storage rooms. Satisfactory arrangements of passageways and bins for various-sized houses are shown in the floor plans of figures 7 to 10.

The bins are made as follows: For the corner and middle supports, 2 by 4 inch scantlings are set up, the lower end nailed to the floor and

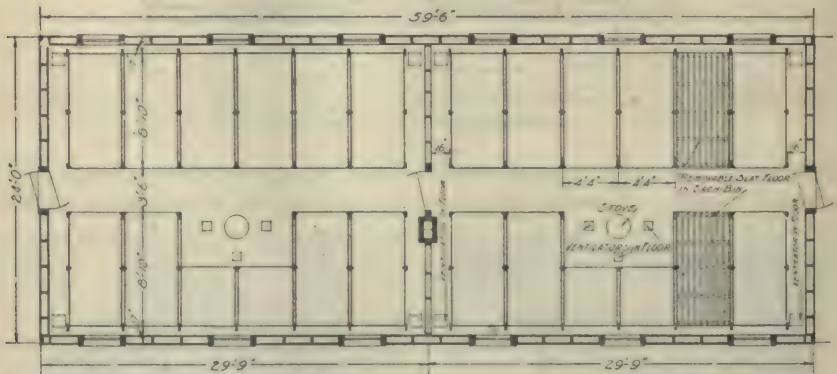


FIG. 9.—Floor plan of a 24 by 60 foot sweet-potato storage house having a capacity of about 5,200 bushels.

the upper to the crosspieces used for tying the sides together. Over the supports, 1 by 4 inch boards are nailed, leaving a 1-inch space between them. The ends of the bins parallel with the outside wall of the house must be built first, because there is not room enough to work between the bin and the outside wall. In making the slat floors, 2 by 4 inch scantlings are cut to go across the bin and placed on edge, one near each end and one in the center. To these 1 by 4 or 1 by 6 inch boards are tacked, leaving a 1-inch space between them. If left loose, the slat floor racks can be taken out when the house is cleaned and disinfected during the summer. The size of the bins will depend somewhat on the arrangement and size of the house, but it is not advisable to make them more than 5 feet wide, 6 to 8 feet deep, and 10 to 12 feet long. There should be a 6 to 12 inch space between the walls and the bins, to allow a circulation of air. It is necessary to slat up both sides of the scantlings between the bins, in order to leave

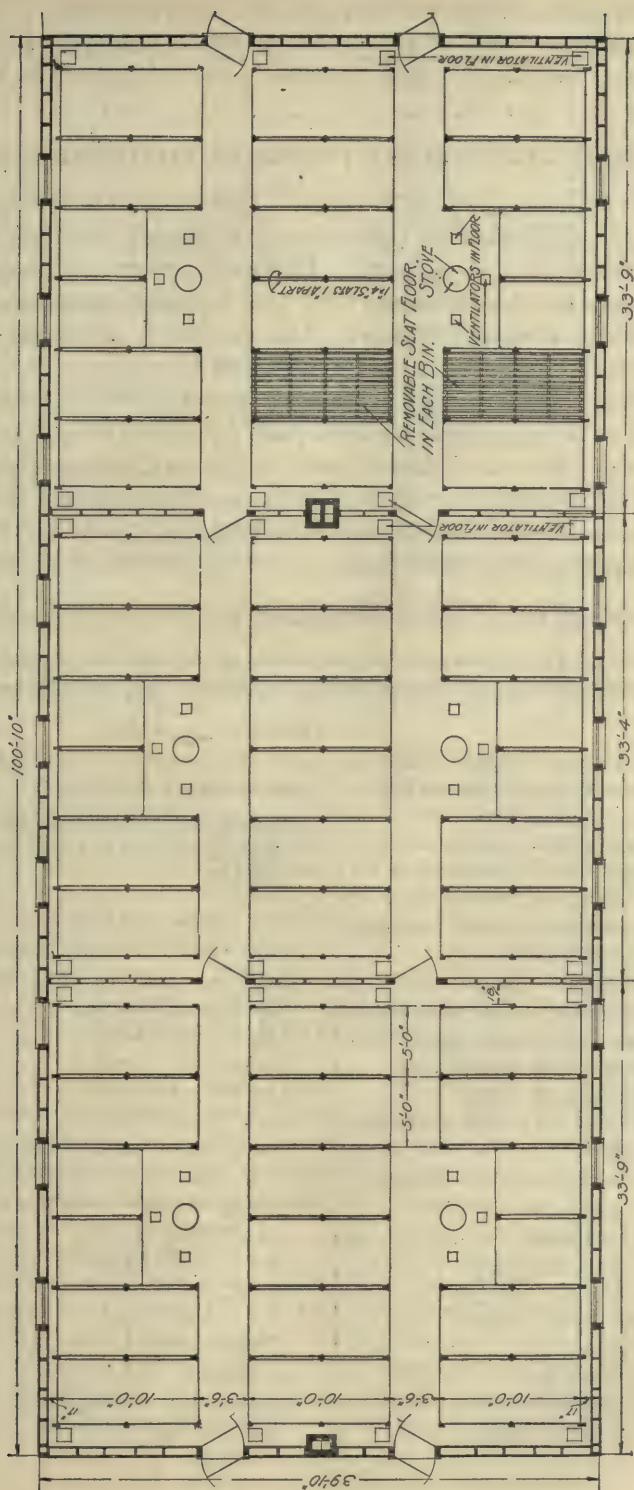


Fig. 10.—Floor plan of a 40 by 100 foot sweet-potato storage house having a capacity of 15,500 bushels.

an air space between the potatoes in the different bins. The construction here described allows a 4-inch space between the bins, a 4-inch space under the bins, and 6 inches between the bins and outside walls.

MATERIALS REQUIRED FOR HOUSES OF DIFFERENT SIZES.

It is not practicable to give the cost of a sweet-potato storage house because of the difference in the price of materials and labor in the various sections of the country. However, given the amount of materials required, it will be easy for one to secure estimates on the cost of building a storage house. The estimates given are for the houses illustrated in figures 1 to 3, 5, and 7 to 10.

Anyone who contemplates building a sweet-potato storage house after the plans shown in this bulletin can obtain working drawings by writing to the Office of Public Roads and Rural Engineering of the United States Department of Agriculture, Washington, D. C., for any of the plans for the four houses illustrated in figures 1 to 3, 5, and 7 to 10. In requesting plans, state which one of the four is desired.

MATERIALS REQUIRED FOR A 12 BY 16 FOOT STORAGE HOUSE OF 500 BUSHELS CAPACITY.

Quantities are for dimensions shown on the drawing and must be altered if dimensions are changed. Footings should be carried below frost line or to solid ground.

Concrete.

Mixture.—One part Portland cement, three parts sand, and five parts gravel or broken stone; or, one part Portland cement and six parts bank-run gravel. Quantities: Cement, 6 sacks; sand, 20 cubic feet; gravel, 31 cubic feet. Or, cement, 6 sacks, bank-run gravel, 1.5 cubic yards.

Chimney. 190 bricks.

Mixture for mortar.—One part Portland cement, three parts sand. Cement, 1 sack; sand, 4 cubic feet.
1—6" terra-cotta thimble.
6 linear feet of 8" by 8" terra-cotta flue lining.

Lumber.

Girders.—2—6" by 10" by 12'.
3—6" by 10" by 16'.
Joists.—17—2" by 8" by 12'.
Studs.—19—2" by 4" by 16'.
Plates.—6—2" by 4" by 16'.
6—2" by 4" by 12'.
Ties.—4—2" by 4" by 12'.
Rafters.—11—2" by 4" by 16'.
1—1" by 6" by 18' (ridge.)

Lumber—Continued.

Sheathing (includes 20 per cent waste).—
2,084 feet b. m. 1" by 6".

Flooring (includes 25 per cent waste).—
1,000 feet b. m. 1" by 4", tongue and groove.

Drop siding.—615 feet b. m. 1" by 6" (includes 20 per cent waste).

Platform.—3—2" by 4" by 12'.

1—2" by 8" by 14'.

3—2" by 8" by 12'.

1—4" by 4" by 6'.

1—2" by 12" by 12'.

2—1" by 10" by 14'.

Trim (surfaced 4 sides).—4—1½" by 4½" by 18'.

4—1½" by 4½" by 14'.

2—1" by 6" by 16'.

2—1" by 8" by 16'.

2—1" by 8" by 12'.

2—1" by 6" by 18'.

70 linear feet 1½" by 2½" drip molding.

Ventilators in roof (surfaced 4 sides).—
1—1" by 12" by 14'.

Lumber—Continued.

Bins.—6—2'' by 4'' by 16'.

3—2'' by 4'' by 12'.

2—2'' by 2'' by 16'.

6—1'' by 2'' by 16'.

34—1'' by 4'' by 12'.

65—1'' by 4'' by 14'.

Chimney.—1—2'' by 6'' by 12' (platform).

Roof covering.—As desired, for 290 square feet.

Building paper.—40 squares.

Miscellaneous.

2 double-hung sash and frames, for 12 lights 9'' by 12'' glass.

1 No. 2 glazed door, 3' by 7', 6 lights 8'' by 10'' glass.

1 frame for glazed door 3' by 7'.

3 pairs 6'' galvanized T hinges.

1 pair 2½'' by 2½'' galvanized hinges.

1 pair 3½'' by 3½'' loose pin butts.

Miscellaneous—Continued.

1—2'' cleat.

1—2'' window pulley.

12 feet of ¼'' rope.

4 bolts ¾'' by 3'', with 4'' rings.

9—¾'' by 24'' bolts, nuts, and washers.

4 square feet ¼'' mesh wire cloth.

2—¼'' by 2½'' wrought-steel straps.

4—¼'' by 3'' lag screws.

4 feet galvanized-iron flashing, 12'' wide.

Fastenings for windows, doors, and shutters, as desired.

Nails.

4 pounds 20-penny.

17 pounds 10-penny.

85 pounds 8-penny.

10 pounds 6-penny.

3 pounds 8-penny finishing.

Paint.

For three outside coats, 4 gallons.

MATERIALS REQUIRED FOR A 20 BY 40 FOOT STORAGE HOUSE OF 2,500 BUSHELS CAPACITY.

Quantities are for dimensions shown on the drawings and should be altered if dimensions are changed. Footings should be carried below frost line or to solid ground.

Concrete.

Mixture.—One part Portland cement, three parts sand, and five parts gravel or broken stone; or, one part Portland cement and six parts bank-run gravel. Quantities:

Constituents.	Walls.	Piers.
Cement.....	79 sacks.....	7 sacks.
Sand.....	8.7 cu. yds.....	21 cu. ft.
Gravel.....	14.5 cu. yds.....	34 cu. ft.
Or—		
Cement.....	79 sacks.....	7 sacks.
Bank-run gravel....	19 cu. yds.....	1.8 cu. yds.

Chimney. 500 bricks.

Mixture for mortar.—One part Portland cement, three parts sand. Cement, 3 sacks; sand, 10 cubic feet.

1—6'' terra-cotta thimble.

18 linear feet of 8'' by 8'' terra-cotta flue lining.

Lumber.

Girders.—2—6'' by 10'' by 16'.

1—6'' by 10'' by 8'.

Sills.—24—2'' by 8'' by 12'.

Lumber—Continued.

Studs.—26—2'' by 4'' by 18' (sides).

3—2'' by 4'' by 18' (over windows).

12—2'' by 4'' by 18'.

1—2'' by 4'' by 16' (ends).

2—2'' by 4'' by 12'.

4—2'' by 4'' by 10'.

1—2'' by 4'' by 12' (over doors).

Plates.—24—2'' by 4'' by 10' (sides).

12—2'' by 4'' by 10' (ends).

Rafters.—44—2'' by 6'' by 14'.

2—1'' by 6'' by 12' (ridge).

2—1'' by 6'' by 10' (ridge).

Joists.—62—2'' by 10'' by 10'.

160 linear feet 1'' by 3'' (bridging).

Sheathing (includes 20 per cent waste).—

2,568 feet b. m. 1'' by 6'' (roof).

1,032 feet b. m. 1'' by 6'' (ceiling).

1,200 feet b. m. 1'' by 6'' (inside walls).

1,344 feet b. m. 1'' by 6'' (outside walls).

960 feet b. m. 1'' by 6'' (subflooring).

Drop siding (includes 20 per cent waste).—1,344 feet b. m. 1'' by 6''.

Lumber—Continued.

Flooring (tongue and groove, includes 25 percent waste).—

1,075 feet b. m. 1" by 4" (ceiling).

1,400 feet b. m. 1" by 4" (walls).

1,000 feet b. m. 1" by 4" (floor).

Ventilators in roof.—2—1" by 12" by 14' (surfaced 4 sides).

Trim (surfaced 4 sides).—9—1½" by 4½" by 14' (windows and doors).

4—1½" by 4½" by 18' (corners).

4—1½" by 4½" by 14' (end fascia).

12—1" by 8" by 10' (baseboard).

4—1" by 8" by 12' (ridge).

4—1" by 8" by 10' (ridge).

170 linear feet 1½" by 2½" (drip molding).

Bins.—29—2" by 4" by 18' (studs).

10—2" by 2" by 18' (nailing strips).

20—1" by 6" by 12' (ties at partitions).

20—1" by 6" by 16'.

32—1" by 2" by 18' (cleats for loose boards).

8—2" by 6" by 10' (over bins).

18—2" by 4" by 12' (under removable floors).

418—1" by 4" by 16' (slats for bin sides).

72—1" by 4" by 16' (slats for removable floors).

162—1" by 4" by 16' (loose slats).

Screens (surfaced 4 sides, for cellar windows).—3—¾" by 2" by 16'.

Battens (for shutters and doors).—8—1" by 6" by 10'.

Platforms.—5—2" by 8" by 12' (sides and floor).

1—2" by 8" by 14' (sides).

2—2" by 12" by 12' (carriages).

2—4" by 4" by 12' (posts).

2—2" by 4" by 12' (nailing strip).

Lumber—Continued.

3—2" by 4" by 14' (joists). 2—2" by 10" by 14' (treads).

Roof covering.—As desired, for 1,070 square feet.

Building paper.—58 squares.

Miscellaneous.

6 cellar frames and sash for 3 lights 8" by 10" glass.

6 double-hung sash and frames for 12 lights 9" by 12" glass.

2 No. 2 glazed doors, 3' by 7', 6 lights 8" by 10" glass.

2 frames, for glazed doors, 3' by 7'.

8 pairs 2½" by 2½" galvanized hinges.

8 pairs 6" galvanized T hinges.

2 pairs 3½" by 3½" loose pin butts.

2—2" window pulleys.

2 screw eyes.

2—2" cleats.

24—feet of ¼" rope.

4 bolts, ¾" by 3", with 4" rings.

30 square feet ¼" mesh galvanized-wire cloth.

24—¾" by 18" bolts, nuts, and washers.

6 linear feet galvanized-iron flashing, 12" wide.

4—¼" by 2½" wrought-steel straps.

8—¼" by 3" lag screws.

Fastenings for windows, doors, and shutters, as desired.

Nails.

2 pounds 30-penny.

10 pounds 20-penny.

30 pounds 10-penny.

300 pounds 8-penny.

100 pounds 6-penny.

10 pounds 8-penny finishing.

Paint.

For three outside coats, 8 gallons.

MATERIALS REQUIRED FOR A 24 BY 60 FOOT STORAGE HOUSE OF ABOUT 5,200 BUSHEL CAPACITY.

Quantities are for dimensions shown on the drawings and should be altered if dimensions are changed. Footings should be carried below frost line or to solid ground.

Concrete.

Mixture.—One part Portland cement, three parts sand, and five parts gravel or broken stone; or, one part Portland cement and six parts bank-run gravel. Quantities:

Constituents.	Walls.	Piers.
Cement.....	109 sacks.....	15 sacks.
Sand.....	12 cu. yds.....	1.5 cu. yds.
Gravel.....	20 cu. yds.....	2.6 cu. yds.
Or—		
Cement.....	109 sacks.....	15 sacks.
Bank-run gravel.	24 cu. yds.....	3.3 cu. yds.

Chimney. 500 bricks.

Mixture for mortar.—One part Portland cement, three parts sand. Cement, 3 sacks; sand, 10 cubic feet.
2—6" terra-cotta thimbles.
38 linear feet 8" by 8" terra-cotta flue lining.

Lumber.

Girders.—4—6" by 10" by 18'.
3—6" by 10" by 16'.
Sills.—28—2" by 8" by 12'.
Studs.—62—2" by 6" by 18'.
4—2" by 6" by 14'.
Plates.—42—2" by 6" by 12'.
Rafters.—62—2" by 6" by 16'.
6—1" by 6" by 12' (ridge).
Joists.—48—2" by 10" by 16'.
24—2" by 10" by 18'.
400 linear feet 1" by 3" (bridging).
Sheathing.—11,220 feet b. m. 1" by 6" (includes 20 per cent waste).
Flooring (tongue and groove, includes 25 per cent waste).—6,500 feet b. m. 1" by 4".
Trim (surfaced 4 sides).—12—1½" by 4½" by 14'.
4—1½" by 4½" by 18'.
4—1" by 6" by 16'.
14—1" by 8" by 12'.
200 linear feet 1½" by 2½" drip molding.

Lumber—Continued.

Ventilators in roof.—4—1" by 12" by 14' (surfaced 4 sides).

Bins.—632—1" by 4" by 18'.

95—1" by 4" by 16'.

40—2" by 4" by 18'.

14—2" by 2" by 18'.

66—1" by 6" by 12'.

40—1" by 2" by 16'.

8—2" by 6" by 10'.

2—2" by 6" by 18'.

Drop siding.—2,000 feet b. m. 1" by 6" (includes 20 per cent waste).

Dividing partitions.—10—2" by 4" by 18'.

5—2" by 4" by 12'.

2—2" by 4" by 14'.

Lining.—Included under "Flooring."

Screens (for cellar sash).—6—¾" by 2" by 16" (surfaced 4 sides).

Platforms.—6—2" by 4" by 12'.

2—2" by 8" by 14'.

6—2" by 8" by 12'.

1—4" by 4" by 12'.

2—2" by 12" by 12'.

4—2" by 10" by 14'.

Roof covering.—As desired, for 1,860 square feet.

Building paper.—103 squares.

Miscellaneous.

12 cellar frames and sash, for 3 lights 8" by 10" glass.

12 double-hung sash and frames for 12 lights, 9" by 12" glass.

2 No. 2 glazed doors, 3' by 7', 6 lights 8" by 10" glass.

2 frames for glazed doors 3' by 7', 6" studs.

16 pairs 2½" by 2½" galvanized hinges.

2 pairs 3½" by 3½" galvanized loose-pin butts.

15 pairs 6" T hinges.

4—2" window pulleys.

4 screw eyes.

64 feet of ¼" rope.

Miscellaneous—Continued.

- 4—2" cleats.
 8 bolts $\frac{3}{4}$ " by 3", with 4" rings.
 50 square feet $\frac{1}{4}$ " mesh galvanized-wire cloth.
 8 feet galvanized-iron flashing, 12" wide.
 40— $\frac{3}{8}$ " by 18" bolts, nuts, and washers.
 4— $\frac{1}{4}$ " by 2 $\frac{1}{2}$ " by 18" wrought-steel straps.
 8— $\frac{1}{4}$ " by 3" lag screws.

Miscellaneous—Continued.

Fastenings for windows, doors, and shutters, as desired.

Nails.

- 10 pounds 20-penny.
 180 pounds 10-penny.
 400 pounds 8-penny.
 50 pounds 6-penny.
 15 pounds 8-penny finishing.

Paint.

For three outside coats, 10 gallons.

MATERIALS REQUIRED FOR A 40 BY 100 FOOT STORAGE HOUSE OF ABOUT 15,500 BUSHELS CAPACITY.

Quantities are for dimensions shown on the drawings and should be altered if dimensions are changed. Footings should be carried below frost line or to solid ground.

Concrete.

Mixture.—One part Portland cement, three parts sand, and five parts gravel or broken stone; or, one part Portland cement and six parts bank-run gravel. Quantities:

Constituents.	Walls.	Piers.
Cement.....	185 sacks.....	34 sacks.
Sand.....	21 cu. yds.....	4 cu. yds.
Gravel.....	34.5 cu. yds.....	6.5 cu. yds.
Or—		
Cement.....	185 sacks.....	34 sacks.
Bank-run gravel.....	44 cu. yds.....	8 cu. yds.

Chimney. 1,700 bricks.

Mixture for mortar.—One part Portland cement, three parts sand. Cement, 10 sacks; sand, 2 cu. yds.
 6—6" terra-cotta thimbles.
 36 linear feet 8" by 8" terra-cotta flue lining.

Lumber.

- Girders.*—6—6" by 10" by 10'.
 14—6" by 10" by 16'.
 1—6" by 10" by 14'.
Sills.—35—2" by 8" by 16'.
Studs.—62—2" by 6" by 18' (sides).
 9—2" by 6" by 18' (over windows).
 22—2" by 6" by 18' } (ends).
 20—2" by 6" by 10' }
 2—2" by 6" by 12' (over doors).
Plates.—52—2" by 6" by 12' (sides).
 16—2" by 6" by 10' (ends).
Bin posts under purlins.—36—2" by 4" by 16'.
 24—2" by 4" by 14'.

Lumber—Continued.

- Purlins.*—24—2" by 6" by 12'.
 12—2" by 6" by 10'.
Braces under purlins.—12—2" by 6" by 14'.
Rafters.—130—2" by 6" by 12'.
 130—2" by 6" by 14'.
 12—1" by 6" by 10' (ridge).
Joists.—202—2" by 10" by 12'.
 101—2" by 10" by 18'.
 800 linear feet 1" by 3" (bridging).
Sheathing (includes 20 per cent waste).—11,870 feet b. m. 1" by 6" (roof).
 5,280 feet b. m. 1" by 6" (ceiling).
 2,920 feet b. m. 1" by 6" (inside walls).
 3,450 feet b. m. 1" by 6" (outside walls).
 4,800 feet b. m. 1" by 6" (sub-floor).
Drop siding (includes 20 per cent waste).—3,400 feet b. m. 1" by 6".
Flooring (tongue and groove, includes 25 per cent waste).—5,500 feet b. m. 1" by 4" (ceiling).
 3,440 feet b. m. 1" by 4" (walls).
 5,000 feet b. m. 1" by 4" (walls).
Trim (surfaced 4 sides).—22—1 $\frac{1}{2}$ " by 4 $\frac{1}{2}$ " by 14' (windows and doors).
 5—1 $\frac{1}{2}$ " by 4 $\frac{1}{2}$ " by 18' (corners).
 8—1 $\frac{1}{2}$ " by 4 $\frac{1}{2}$ " by 12' (end fascia).
 24—1" by 8" by 12' (baseboards).
 18—1" by 6" by 12' (roof ridge).
 350 linear feet 1 $\frac{1}{2}$ " by 2 $\frac{1}{2}$ " drip molding.

Lumber—Continued.

Ventilators in roof.—6—1" by 12" by 14' (surfaced 4 sides).

Dividing partitions.—

8—2" by 4" by 10' (plates).

8—2" by 4" by 18' }

8—2" by 4" by 16' }

12—2" by 4" by 14' (studs).

8—2" by 4" by 12' }

8—2" by 4" by 10' }

2—2" by 4" by 12' (over doors).

2,655 feet b. m. 1" by 4" tongue-and-groove flooring (includes 25 per cent waste).

Screens (at cellar windows).—9— $\frac{1}{4}$ " by 2" by 16' (surfaced 4 sides).

Bins.—72—2" by 4" by 18' (studs).

21—2" by 2" by 18' (nailing strips).

21—1" by 6" by 18' }

42—1" by 6" by 12' }

21—1" by 6" by 16' }

42—1" by 6" by 10' }

(1)

118—1" by 2" by 18" (cleats for loose boards).

42—2" by 6" by 12' (over bins).

21—2" by 6" by 10' }

77—2" by 4" by 12' (removable floors).

2,166—1" by 4" by 10' (slats for bin

114—1" by 4" by 12' } sides).

462—1" by 4" by 10' (slats for re-

movable floors).

66—1" by 4" by 12' }

1,083—1" by 4" by 10' (loose slats).

Battens (for shutters and outside doors).—22—1" by 6" by 10'.

Platforms.—8—2" by 4" by 10' (nailing strips).

3—2" by 12" by 14' (carriages).

4—4" by 4" by 12' (posts).

1—2" by 8" by 14' (sides and floor-

28—2" by 8" by 10' } ing).

Lumber—Continued.

10—2" by 4" by 14' (joists).

3—2" by 10" by 14' (treads).

Roof covering.—As desired, for 4,950 square feet.

Building paper.—230 squares.

Miscellaneous.

18 cellar frames and sash, for 3 lights 8" by 10" glass.

18 double-hung sash and frames, for 12 lights 9" by 12" glass.

4 No. 2 glazed doors, 3' by 7', 6 lights 8" by 10" glass.

4 frames for glazed doors, 3' by 7', 6" studs.

4 frames for doors, 3' by 7', 4" studs.

24 pairs $2\frac{1}{2}$ " by $2\frac{1}{2}$ " galvanized hinges.

26 pairs 6" galvanized T hinges.

4 pairs $3\frac{1}{2}$ " by $3\frac{1}{2}$ " loose-pin butts.

6—2" window pulleys.

6 screw eyes.

6—2" cleats.

100 linear feet of $\frac{1}{4}$ " rope.

24— $\frac{1}{4}$ " by 3" bolts, with 4" rings.

110 square feet of $\frac{1}{4}$ " mesh galvanized wire cloth.

50— $\frac{5}{8}$ " by 18" bolts, nuts, and washers.

40 linear feet of galvanized iron flashing, 12" wide.

8— $\frac{1}{4}$ " by $2\frac{1}{2}$ " wrought-steel straps.

16— $\frac{1}{4}$ " by 3" lag screws.

Fastenings for windows, doors, and shutters, as desired.

Nails.

12 pounds 30-penny.

25 pounds 20-penny.

77 pounds 10-penny.

930 pounds 8-penny.

190 pounds 6-penny.

30 pounds 8-penny finishing.

Paint.

For three outside coats, 20 gallons.

¹ Ties at partitions. Stagger joints, using 12's with 18's and 16's with 10's.

UTILIZING ABANDONED TENANT HOUSES, WAREHOUSES, AND OTHER STRUCTURES FOR STORING SWEET POTATOES.

On many farms in the South there are abandoned tenant houses and various other buildings that could be converted into sweet-potato storage houses at very little expense. In many towns there are warehouses, store buildings, and other structures that could be utilized to

advantage for storing sweet potatoes. Where such structures are available on the farms or in towns they should be utilized before erecting new houses. The same methods of insulating and ventilating should be used in remodeling old structures as are recommended for new sweet-potato storage houses. Where the interior of the house to be remodeled is not already sheathed it is advisable to nail a layer of 1 by 4 or 1 by 6 inch boards on the studding, then a layer of building paper, and over this matched boards, as shown in figure 4. If the interior is sheathed with only one layer of boards it is a good plan to put on a layer of building paper and then set 2 by 4 inch scantlings against the walls. On these tack another layer of paper and over this a layer of matched 1 by 4 or 1 by 6 inch boards. The tighter the house is made, the less attention is required to keep the temperature and moisture under proper control.

Where only a few bushels of sweet potatoes are to be stored they may be kept in a loft over the kitchen or in any place in the house where the temperature is quite uniform (between 50° and 60° F.) and the air rather dry.

VARIETIES OF SWEET POTATOES FOR MARKET.

The varieties of sweet potatoes to grow depend upon the market to be supplied. The northern and eastern markets prefer a dry, mealy potato, such as the Big-Stem Jersey, Yellow Jersey, Early Carolina, and Gold Coin, although such varieties as the Nancy Hall, Dooley, and Triumph have been sold to good advantage on the central western markets; in fact, it is reported that southern-grown sweet potatoes of the Nancy Hall variety commanded the highest price on one of the largest markets in 1915 and 1916. The main reason that southern-grown sweet potatoes have not been in greater demand on the northern markets is because they have been poorly graded and packed. The markets of the South prefer the moist varieties, such as Nancy Hall, Dooley, Pumpkin Yam, Southern Queen, Georgia Yam, and Porto Rico. The Nancy Hall is grown on a larger scale than any other variety. The Porto Rico is becoming very popular, and large quantities are being planted in regions where it is well known. The Triumph, a dry, white-fleshed sweet potato, is grown to some extent for shipping to northern markets early in the season.

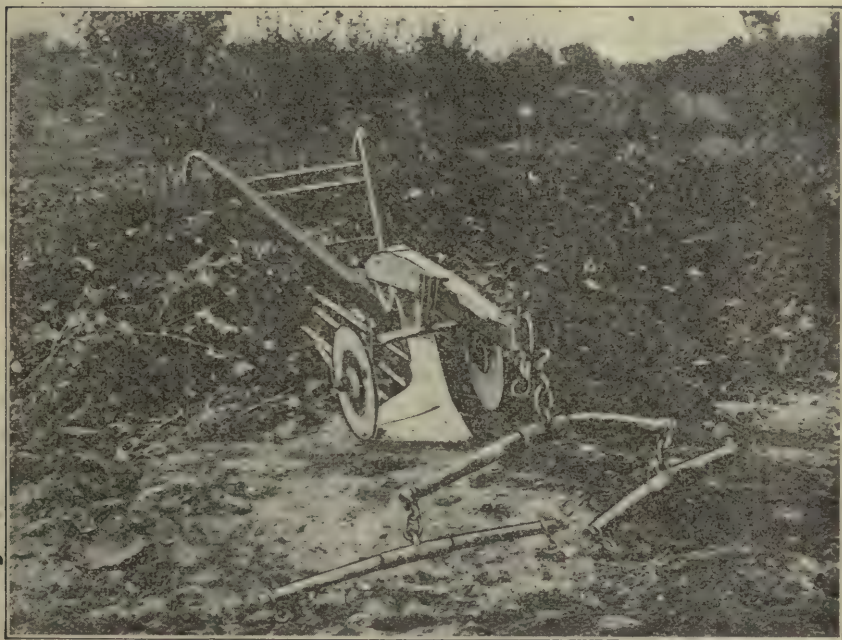
The southern farmers should supply their own markets before trying to ship their potatoes to northern markets. During late winter and early spring many large towns and cities of the South are poorly supplied, because of lack of storage facilities. With storage houses, these markets could be supplied with southern-grown potatoes throughout the season. The markets of the West will take the moister fleshed potatoes grown in the South, and a good trade could

be built up in this region if the growers would use greater care in grading and packing.

While the varieties of sweet potatoes now grown in the South are preferred by the southern people, the dry, mealy roots sell best in the markets of the North. The grower should aim to give the consumers what they want, and for northern markets the dry or semimoist varieties should be grown, regardless of the grower's preference.

HARVESTING SWEET POTATOES.

Careful handling is one of the essentials in keeping sweet potatoes, and there is no more important place to practice it than in the field at digging time. The implement used to dig sweet potatoes should



P16547HP

FIG. 11.—A type of digger with rolling colters attached to the beam, often used for digging sweet potatoes.

be one that does not cut or bruise the roots. One of the best types of diggers is a plow with rolling colters on the beam to cut the vines and with rods attached to the moldboards to free the roots from the soil and vines (fig. 11). A "middle buster" is also a good implement for digging sweet potatoes. After the potatoes are dug they should be scratched out by hand and allowed to remain exposed long enough to dry. They should never be thrown from one row to another, thrown loose into the wagon bed, or put into bags. The digging should be done, if possible, when the weather is bright and the soil dry.

Sweet potatoes should be graded in the field, in order to reduce the cost of handling to a minimum. A good plan is to go over the rows

and pick up the sound, marketable potatoes in one basket, then gather all the seed stock in another basket or box and put the injured ones in still another. These boxes or baskets should be loaded on a wagon with springs and hauled direct to the storage house. If the potatoes are to be stored in baskets, boxes, or crates, the different grades should be put by themselves, and when stored in bulk they should be placed in separate bins. By following this method it will not be necessary to grade the potatoes at the storage house when putting them in. This will effect a saving of time, reduce the loss by decay, and save the cost of extra handling. The potatoes should be emptied into the bins as carefully as possible, to prevent bruising. Sweet potatoes can be stored in boxes, hampers, baskets, or bins with satisfactory results. The preference of the individual grower will determine the method to be employed.

Each year, after the sweet potatoes have been marketed, the storage house should be thoroughly cleaned and disinfected before it is used again. All dirt and refuse should be cleaned out and all parts of the interior sprayed or washed thoroughly with a solution of formalin (1 pint of formalin to 10 or 15 gallons of water). Diseased roots should not be thrown on the manure pile or on land to be used for sweet potatoes; the safest plan is to burn them.

FILLING THE BINS.

In filling the storage house, the workmen should begin at the back end of the bins and pour a layer of sweet potatoes about 2 feet deep in all of the bins rather than fill one bin at a time. If the bins are 8 or 10 feet long, it is a good plan to divide them into two parts. By nailing cleats to the middle support of the bins, as shown in figures 7 to 10, the partition can be raised as the bins are filled. The partition boards should have some space between them to allow free circulation of air. A 1-inch block between the boards will be satisfactory to separate them. By dividing the bins in this way, the back of the bin can be filled without climbing over the potatoes in the front part. When taking the potatoes out, those in one section of a bin can be removed without disturbing the remainder. This is very important where they are sold in small quantities.

CURING SWEET POTATOES.

While the newly dug sweet potatoes are being brought in, a fire should be kept up in the storage house to dry off the moisture. A temperature of 80° to 85° F., with plenty of ventilation, should be maintained for 10 days or 2 weeks, depending on weather conditions and the variety of potatoes. Ventilation is absolutely neces-

sary, and even if it is not possible to keep the temperature up to 80° F., it is necessary to leave the doors, windows, and ventilators open, so as to drive out the moisture-laden air. The doors and windows may be closed at night, and should be kept closed on cloudy days. Some of the ventilators in the floor and through the ceiling should be kept open throughout the curing period, even in cloudy or rainy weather. The air inside the house should be kept warmer than the outside air during the curing period. This will prevent moisture from being deposited on the walls. As the air warms, it expands and takes up moisture. When it cools it contracts and gives up its moisture. This makes it important to get the moisture-laden air out of the house by ventilation. When the potatoes are thoroughly dried or cured, the temperature should be gradually reduced to 55° F. and kept as near that point as possible during the remainder of the storage period. If the temperature goes below 48° F., a fire should be made or the house opened in the middle of the day whenever the temperature on the outside is high enough. When the temperature goes above 60° F., the house should be opened in the cool of the day, to lower the temperature to 54° or 55° F., and then closed. In mild weather the ventilators in the roof may be partly open all the time, but they should be closed in cloudy or cold weather.

METHODS OF HEATING A STORAGE HOUSE.

A small house can be heated with a sheet-iron stove that will burn knots and other pieces of wood. Coal stoves may be used if preferred, but air-tight wood stoves will serve the purpose. It requires a longer time to get up heat with a coal stove than with a wood stove, and this is one disadvantage in using coal. Often all that is necessary to raise the temperature a few degrees is to start a little wood fire. In a commercial storage house a hot-air heater or a hot-water boiler, with pipes around the walls, would be preferable to a stove, but a house that will hold as many as 10,000 to 25,000 bushels of sweet potatoes may be heated with good stoves. The location of the stoves in the house depends on the size of the house and the direction of the cold winds. Ordinarily, where one stove is used, it is placed near the center of the house, but if the cold wind strikes one end the stove should be in that end. Some storage houses have a small stove in each end, and this is the best arrangement for a long house. Others have a stove in one end, with the pipe entering the chimney at the other end. Considerable open space should be left around the stove to prevent the potatoes from being injured by excessive heat. In large houses it is desirable to put in partitions to make separate rooms. Each room should have

a stove or other independent heating unit. Small storage houses are sometimes heated with oil stoves with satisfactory results. In most sections of the South it is not necessary to keep heat in the storage house much of the time. It is only necessary to build a fire when the temperature in the house goes below 48° F. or during wet weather, when moisture is likely to deposit on the walls. When the outside temperature goes to 60° F. or above during the day, the house may be opened for a few hours, provided the atmosphere is fairly dry, in order to raise the temperature inside to the desired point. When the temperature reaches 55° F. the house should be closed. By giving close attention to opening and closing the house,



P1308HP

FIG. 12.—A pile of sweet potatoes ready to be covered with cane tops and soil. Note the ventilating hole which extends through the center of the pile.

very little artificial heat will be needed in the lower South after the curing period.

STORAGE PITS AND CELLARS.

While it is advisable to build storage houses similar to the types already described, it is nevertheless realized that it will be many years before sufficient houses are available to care for the entire crop. Therefore, the best methods of storing in pits or banks and in outdoor cellars are here described. The main disadvantages in the pit or bank method of storage are (1) the large amount of loss due to decay; (2) the inferior quality of the sound potatoes, due to lack of proper curing; (3) the loss on the market, because banked potatoes will keep for such a short period after being removed; and (4) the inconvenience of getting the potatoes when needed, especially during cold or rainy weather. If it is impossible to build a storage house the potatoes should be cared for in some other way, and it is much better to store in pits or outdoor cellars than not to store them at all. By using the

best methods of banking known, the loss by decay can be materially reduced but not eliminated, because it is impossible to control the moisture and temperature.

Storage pits should be located where the drainage is good. In making a pit a little of the surface soil is thrown back to form a level bed of the size desired. It is a good plan to dig two small trenches across the bed at right angles to each other, to provide for ventilation at the bottom. Lay boards or place troughs over the trenches, and at the point where the trenches cross set a small box on end to form a flue up through the pile of potatoes, as shown in figure 12. The earth floor of the pit is covered with 4 or 5 inches of straw, hay, leaves, or pine needles, and the potatoes are placed in a conical pile around the flue. A covering of straw, hay, or similar material is put on the pile



P1311HP

FIG. 13.—A number of sweet-potato banks, illustrating the method of ventilation by the use of troughs at the top of each pile.

and over this a layer of soil. The covering of soil should be only a few inches thick at first, but increased as the weather gets cold. Keep the ends of the trenches and flue open until it is necessary to close them to keep out the frost. It is better to make several small pits rather than one large one, because it is best to remove the entire contents when the pit is opened. Figure 13 shows a number of pits with a trough ventilator placed over the top of each pile of potatoes.

A type of storage cellar similar to the one shown in figure 14 is often used in the South for storing sweet potatoes. This form of storage is much better than pits or banks. The potatoes can be cured in the outdoor cellar, and it is easier to get them out when wanted for the table or for market. A good type of outdoor cellar can be made as follows: Set a line of posts for the center supports and on these posts

put a ridgepole. Against the ridgepole place one end of planks, poles, or slabs, with their opposite ends resting on the ground on either side. The ends of the inclosure are boarded up, a door being provided in one end. The structure is covered with sod to a thickness of 5 or 6 inches. It is a good plan to put a ventilator through the top and to leave two or three openings in the sides near the ground. Provision should be made to close all these openings during cold or wet weather. By placing a small stove in the storage cellar the potatoes can be cured in the way that has been described for the storage house. The potatoes are usually piled on a layer of straw, leaves, or pine needles placed on the ground. A better method is to build a slat floor a few



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FIG. 14.—A type of outdoor cellar used in some sections of the South for storing sweet potatoes. This structure should have openings near the bottom and through the top for the purpose of ventilation.

inches from the ground and pile the potatoes on the floor. This floor will allow the circulation of air under the potatoes, which will aid in curing them.

MARKETING SWEET POTATOES.

One reason why southern farmers have not received better prices for their sweet potatoes is that they have not used proper methods of handling and marketing. In many cases the potatoes are badly bruised and cut in digging, put in bags or rough barrels without grading, and rushed on the market when there is an oversupply. The secrets of success in getting high prices are to carefully grade, clean, and pack the product and to put it upon the market when there is a good demand. The greatest demand for sweet potatoes is, as a rule, from the middle of December to the middle of March.

When the potatoes are to be marketed they must be carefully graded, no matter how well the grading had been done when they were

put in the house. The market demands a medium-sized uniform type of sweet potato, free from bruises or decayed spots. In grading, the large, overgrown, crooked, broken, or bruised roots should be kept at home for feeding or for canning. The best potatoes will bring a higher price when separated from the culls. Two market grades are sometimes made, the "extra selects" or "primes" and the "seconds" or "pie stock," but the southern farmer will do well to make just one market grade and keep the others for feeding to his live stock.

After careful grading, the sweet potatoes should be put in clean, neat, attractive packages. Bags should never be used, as the potatoes in them become badly bruised when handled. The standard



FIG. 15.—Hampers of sweet potatoes separated into two grades. This type of package is used to a considerable extent by growers in New Jersey.

veneer potato barrel with a burlap cover is often used in summer or autumn, but for winter shipment the double-headed stave barrel or tight box is used. The smaller type of package, such as the bushel hamper (fig. 15.), bushel box, or basket, is becoming more popular each year. A neat and attractive package of well-graded potatoes will bring a good price at almost any time, even when the market is overstocked with inferior goods.

Sweet potatoes when shipped during the winter must be protected from the cold. When a potato becomes chilled its quality is impaired, and decay soon follows. In cold weather the package should be covered with paper and the cars heated, in order to prevent chilling the potatoes. Some shippers find it an advantage to line their baskets and barrels with paper.

superceded by leaflet no. 377

THE CONTROL OF THE CLOVER-FLOWER MIDGE

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Cereal and Forage Insect Investigations



FARMERS' BULLETIN 971

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C.

June, 1918

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IT IS DESIRABLE at this crisis to call the attention of the farmers to the great need of producing a maximum clover-seed crop and also to the method of controlling the clover-flower midge which is one of the important factors in producing a crop.

Tiny maggots in red-clover flowers prevent the seeds from maturing and cause a great reduction in the seed crop. These maggots are the young of a very minute fly known as the clover-flower midge.

The farm practices by which this little pest can be controlled are light or close pasturing, early cutting, clipping, and soiling. These measures are explained on pages 9 to 12.

Infested fields containing mixed timothy and clover should be pastured lightly or the growth clipped back by a mower, probably not later than May in the South or later than the middle of June in the extreme North.

Close pasturing of red clover until late May or early June is an effective means of exterminating the midge. If close pasturing is impracticable, run a mower over the field to clip off the stray heads before starting the seed crop.

Clipping and soiling red clover during the spring and early summer are equally efficacious methods of exterminating the midge, provided young heads of the seed crop are not allowed to appear before the middle of June.

THE CONTROL OF THE CLOVER-FLOWER MIDGE.

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WHY THE MIDGE SHOULD BE CONTROLLED.

THE CLOVER-FLOWER MIDGE¹ (fig. 1) is a small mosquito-like fly which lays its eggs in the young clover heads. The tiny maggots hatching from the eggs destroy the seed-producing parts of the flower and injure the seed crop severely in many States throughout the red-clover regions of the country. This loss is almost entirely preventable by means described in this publication. The present supply of red-clover seed is far below normal, and every possible effort should be made to secure a large crop this season in order to have sufficient seed on hand for planting this most important crop next spring.



DISTRIBUTION.

Although the clover-flower midge did not attract more than local attention until 1878 and was not described until a year later, there is considerable evidence indicating that it was injurious in New England at least 30 years prior to these dates. In America it probably occurs wherever mammoth, crimson, white, or the common red clovers are grown, and it is responsible for very heavy losses to the seed crop in most portions of the country where seed is produced.

FOOD PLANTS AND NATURE OF INJURY.

Red clover is the chief food plant of the clover-flower midge. The midge is rarely found on either white or alsike clover and is never present on these plants in sufficient numbers to affect seed production.

¹ *Dasyneura leguminicola* (Lintner) ; order Diptera, family Itonididae.
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The clover-flower midge is injurious only in its larva or maggot stage. As its name implies, it works in the flower (fig. 2), feeding upon those parts which normally would develop into seed. Although one maggot prevents the formation of only a single seed, the insects can make serious inroads on the seed crop when present in great numbers, as they usually are in infested fields.



FIG. 2.—Clover heads injured by the clover-flower midge.

ent in great numbers, as they usually are in infested fields.

The forage value of red clover is not impaired by midge infestation and the insect, therefore, is of economic importance only in seed-growing districts.

SEASONAL HISTORY IN NORTHERN LATITUDES.

The clover-flower midge passes the winter as a larva, or maggot, generally in a silken case or cocoon on or slightly below the surface of the ground. (See seasonal-history diagram, fig. 3.) Occasionally no cocoons

are spun, especially where ample protection is afforded by the debris covering the surface of the soil. The cocoon is very small, oval, and measures approximately one-tenth of an inch in length and one-twentieth of an inch in diameter. It is constructed of a white papery substance of a leathery consistency and is very difficult to recognize in its natural location because of the coating of soil which usually obscures completely the cocoon proper, causing it to resemble a small lump of earth.

With the first warm days of early spring a few of the larvæ in the cocoons begin to change to the pupa or resting stage, and within a short time the greater portion of the brood has either begun to transform or is in the pupa stage. The pupa period during April and May lasts from two to three weeks, depending upon the season. In seasons of an early spring a few midges complete their transformation and emerge as adults by April 21. If the season is late none may be found in the fields before May 5.

The adult fly (fig. 1) is somewhat smaller than a mosquito and of similar delicate and fragile structure. It is strikingly and beautifully marked, the anterior half being black, with hair-fringed dusky wings, and the posterior half, or abdomen, bright vermilion red in fresh specimens. The abdomen of the female is equipped with a long extensible egg-laying tube, or ovipositor, by means of which the eggs are inserted in the young clover heads. The male differs from the female in being more slender and fragile, and the shorter abdomen is equipped with a pair of clasping organs used in mating.

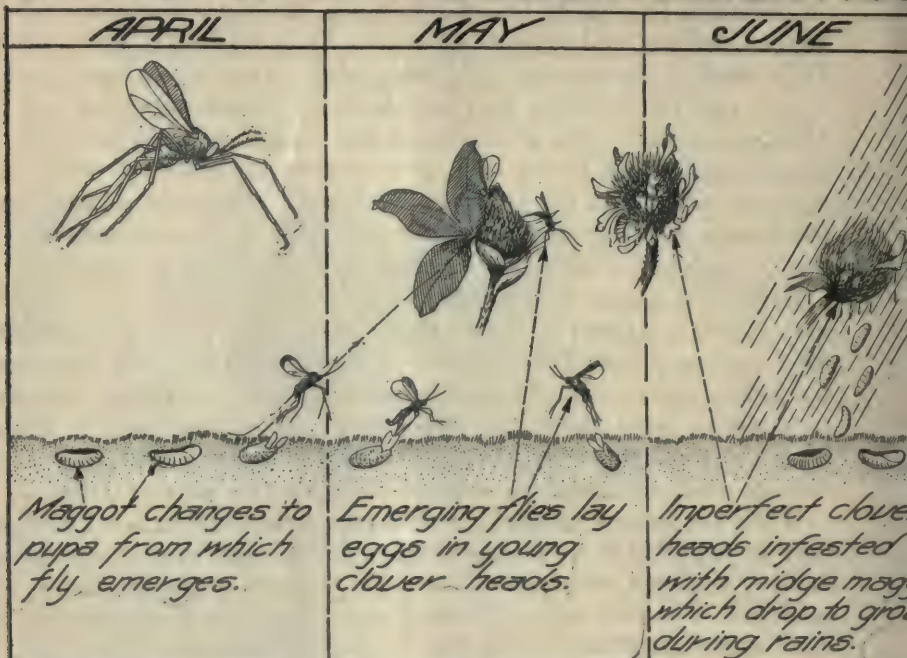
Unless the season is unusually late, by May 5 young clover heads have begun to appear in noticeable numbers and adults are common. The maximum abundance usually is reached between the 18th and the 25th of the month. From this time on there is a gradual decrease in numbers until about the latter part of the first week in June, by which time they have become relatively scarce. Scattered individuals often are found, however, until the latter part of June.

While the foregoing briefly outlines the periods when adult midges may be expected to be on the increase or decrease in a given clover field, it must not be supposed that this increase or decrease is at all uniform. The cool rains of several days' duration which may occur at frequent intervals during the month of May cause a temporary sharp decrease in numbers by checking the emergence of new adults, and a corresponding increase in numbers may always be looked for during the fair weather immediately following such rains.

Upon emerging the females, which are much more plentiful than the males, mate and proceed to the small green clover heads, and in these they lay their eggs. In selecting a place for egg-laying marked preference is shown for young clover heads which are just beginning to appear through the leaf sheath, but the midge if at all numerous frequently will select older heads providing they are still green.

The egg is oval, about three times as long as broad, and barely visible to the naked eye. It is pale yellow at first, but an internal orange spot appears just before hatching. Eggs are found both singly and in clusters, usually stuck to the hairs of the calyx (fig. 4) or to the calyx itself, but not infrequently in clusters just inside the leaf sheath, or on young leaves surrounding the head. When found attached to calyx hairs the eggs occur either singly or in very small clusters. When found between the leaf sheath and the head the clusters are usually larger and contain from 10 to 20 eggs. In the laboratory a single midge has been observed to lay as many as 86 eggs, but as the majority of females when they emerge from cocoons are found to contain over 100 eggs, it is probable that the latter number is a better indication of what the average female actually lays under field conditions. It is not unusual to find considerably more than 100 eggs in and about a single head, or more eggs than there are

LIFE HISTORY OF THE CLOVER FLOWER MIDGE



LIFE HISTORY OF THE MIDGE IN A FIELD OF CLOVER

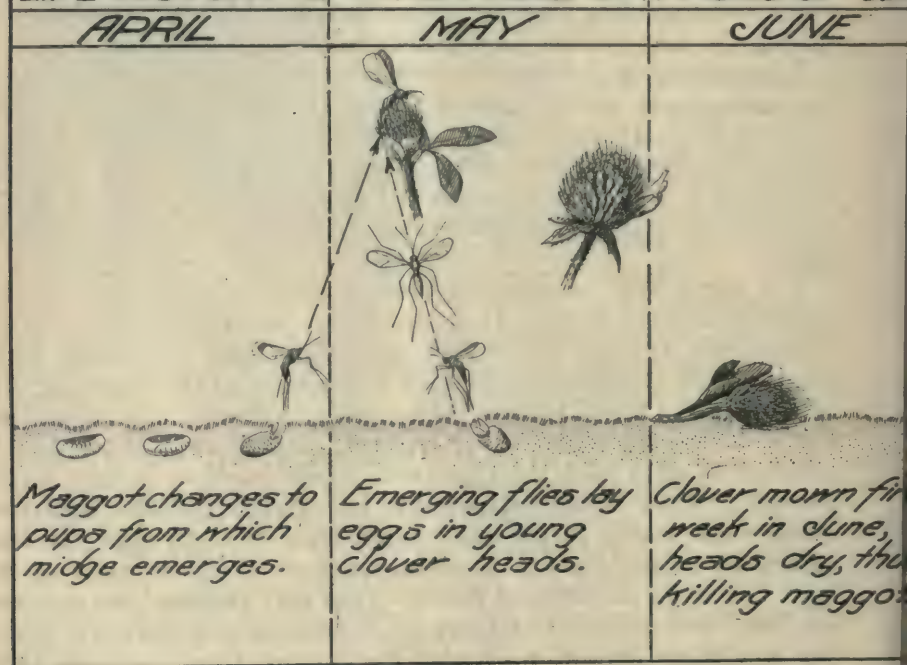


FIG. 3.—Diagram showing se

A FIELD OF CLOVER CUT IN LATE JUNE

JULY	AUGUST	SEPTEMBER
 Summer generation larvae emerges to lay eggs on heads of new crop.	 Heads of clover badly infested, seed crop lost.	 Maggots dropping to ground during fall rains in order to enter soil for the winter.

CUT IN EARLY JUNE AS RECOMMENDED

JULY	AUGUST	SEPTEMBER
 Clover heads free from infestation larvae develop normally.	 Heads full of florets, insuring perfect setting of seed.	 Ripening clover head free from maggots and bearing seed.

florets. A midge generally spends only a few minutes on a head, placing a few eggs in one or two locations and then flying on to another.

The eggs hatch in from three to five days, the length of the egg period varying with the temperature. A larva or maggot upon hatching from the egg is of a watery, pale yellowish color, with an internal

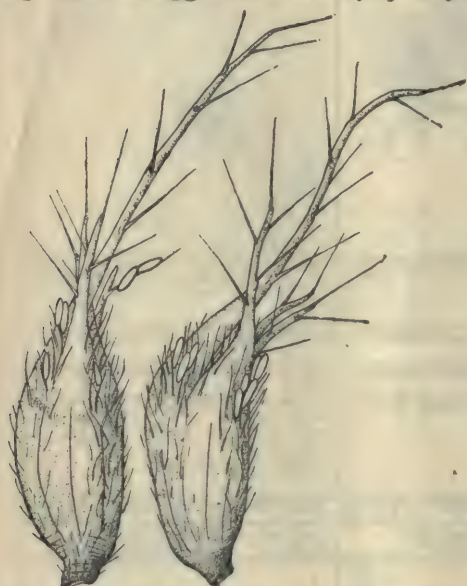


FIG. 4.—Eggs of the clover-flower midge fastened to hairs of calyx in immature red-clover flowers. Highly magnified.

bright orange spot plainly visible to the naked eye. The young legless maggot wriggles to the top of the floret and forces its way inside through the unopened petals. Upon obtaining entrance it works its way down to the young ovary; here it feeds by sucking the juices from this part of the flower, thereby destroying the ovules and thus preventing the formation of seed. Usually only one maggot is found in a single floret, but occasionally two or more are found. A floret infested with a midge larva shows the injury very plainly, as the petals rarely

expand. Infested heads, therefore, are distinguished easily, their imperfect blossoming giving them an irregular or mangy appearance. (Fig. 2 and title-page illustration.)

The time required for a midge larva of the spring generation to complete its growth is approximately four weeks. Few of them complete their development before the last of May, and mature larvæ are not found in the clover heads in noticeable numbers before the end of the first week in June. If the season is exceptionally late it may be impossible to find full-grown maggots before the second or third week of the month. The maggots not only grow rapidly but undergo a pronounced change in color while feeding in the florets. They change gradually from a watery yellow to creamy white as they increase in size, and shortly before reaching maturity become a salmon pink, remaining this color until becoming full grown. Upon reaching maturity the maggots measure approximately one-tenth of an inch in length and entirely fill the florets, taking the place of the seed.

The mature larvæ do not drop at once to the earth to pupate but await sufficient rain thoroughly to moisten the clover heads and the surface of the ground. In some localities it is not uncommon for two

or three weeks to elapse between the date of maturity of a considerable percentage of the midge brood and the occurrence of a sufficient amount of rainfall to bring them out of the heads. After dropping out of the clover heads in June the maggots work their way a short distance into the ground, generally through small cracks in the soil, and lose no time in spinning cocoons similar to those in which the parent generation passed the winter. Unless it becomes exceptionally dry immediately following the spinning of cocoons, the maggots of the summer generation do not remain dormant in the cocoons but pupate at once. The pupa period at this season of the year is generally from two to three weeks, but a spell of dry weather will often lengthen it, and a prolonged drought results in the death of many of the larvæ and pupæ.

The first adults of the summer generation may be expected to appear in the fields any time between July 1 and 15. If there is a fair amount of rainfall during July they emerge in constantly increasing numbers until about July 22. After this date there is a rather rapid decrease in numbers until about the middle of August, when very few are to be found. On the other hand, if there is no rainfall during July this generation will be relatively scarce, reach its height, and completely disappear by the middle of that month. The adults of this generation lay their eggs in the young heads of the seed crop, where they hatch and undergo the same development as described for the spring generation.

The maggots of the summer generation also require approximately four weeks to reach maturity. Most of them complete their growth in early August, but if the summer is dry they frequently remain in the heads until the clover is hulled, or, if the crop is left standing, until the fall rains occur. If sufficient rain falls during the late summer, however, they drop to the ground, pupate, and emerge as adults during late August, September, and, occasionally, well into October. The adults of this third generation lay their eggs in the late heads in the fields from which they emerge. The greater part of their progeny have ample time to complete their growth before killing frosts occur. In any case sufficient progeny of either the second or third generation of midges survive the winter to emerge as adults and propagate during the following spring.

CONTROL MEASURES.

PASTURING.

The practice of pasturing red clover previous to starting a seed crop has proved to be an effective means of midge control in the more northern latitudes. In favorable seasons clover often makes sufficient growth the first year to enable the farmer to begin pasturing in the early fall. Fall pasturing is valuable in that it keeps

down the volunteer heads in which the midge would otherwise secure a foothold in the field the first season. In any event, the clover always makes sufficient growth to permit pasturing the following spring. Spring pasturing exterminates the midge, either directly by the destruction of the clover heads containing the eggs and partially grown larvæ, or indirectly by preventing the heads from forming during the time the adults of the spring generation are laying their eggs. The live stock may be removed from the field the latter part of May or left until early June, depending upon the season and latitude. In case the pasturing has not been close enough to get all of the heads, a mower should be run over the field shortly after the stock is removed in order to cut what remains. This practice not only results in the destruction of the immature midge larvæ which may happen to be present in these heads but also keeps down the weeds that otherwise might be present in the seed crop.

EARLY CUTTING.

As the majority of farmers raising red clover desire to secure both hay and seed crops, the practice of early cutting of the hay crop has to be resorted to in midge-infested districts. This method of midge control has for its object the destruction of the first brood of midge maggots by the cutting off and drying up of their food supply. Early cutting can be practiced successfully by some of the clover-seed growers, but on account of the seasonal variations and general climatic conditions existing in some latitudes it is more difficult to lay down a general rule, stating approximately upon what date to cut each year, than it would be if such conditions were more nearly uniform. To practice early cutting effectively the farmer must not only keep himself informed as to the development of the clover itself (fig. 5) but also as to the development of the midge larvæ within the heads. The changing of tint of the larvæ in the majority of the infested heads in the field from a creamy white to a salmon pink indicates that they are rapidly approaching maturity and that cutting should not be delayed long if the majority of the larvæ are to be killed by this means.

Life-history studies made in the more northern latitudes indicate that few of the maggots of the spring generation ever reach maturity before the end of the first week in June. Therefore it can be safely stated that if the clover is cut about June 1 the cutting will destroy the maggots of the spring generation regardless of the season and will assure an uninfested seed crop, except for such slight infestation as comes from the few scattered individuals that possibly may invade the field from the roadsides or that may be blown over by the wind from a neighboring field. (See fig. 6.)

LATE CUTTING.

Further investigations and experiments, however, have shown that in most seasons the clover can be cut at a slightly later date than June 1 in the more northern latitudes with safety, thus enabling the farmer who is willing to assume the risk of unfavorable weather to obtain a greater amount of forage from his field than would be possible otherwise. Clipping the field at this time should cause the second crop to bloom somewhat earlier, bringing about a condition which should favor the production of seed. The reason that this later cutting is usually effective lies entirely in the fact that midge larvæ, after they complete their development, do not leave the clover heads and drop to the ground to pupate until there has been sufficient rainfall to moisten the field thoroughly. If, therefore, the hay crop is cut and removed at any time between the first week in June and the date of fall thereafter which exceeds approximately one-tenth will be fully as effective as it would have been had while the maggots were still immature.

A good rule to follow is to cut the hay crop during the weather is favorable. If it is rainy day and cut the crop as soon as the sky clears and is settled. In some sections of the country corn and timothy are grown together, in other sections gradually displacing timothy, while in some sections is sometimes the case, the relative proportion is more or less unstable. In each case it is found that a mixed meadow with much timothy requires more mowing than in the case of clover and is more effectively met by pasturing meadows over them and clipping back the growth. In the southern portion of the red-clover belt the cutting of May and in the northern part of the



FIG. 5.—Young clover head showing stage when flower midge lays its eggs.

the 20th of June. This retardation may slightly delay the haying in meadows so treated, but this hay can be cut while the timothy is in bloom or afterwards, as deemed expedient by the owner.

CLIPPING.

Farmers in some localities who desire neither to pasture nor to secure a hay crop follow the practice of cutting their clover back between the 10th and the 25th of May, leaving the clippings on the ground as a mulch. In fields clipped May 15 or earlier, however, the seed crop is apt to be somewhat infested with the midge, owing to the fact that the clover makes sufficient growth to produce young heads in early June before the adult midges of the spring generation



Fig. 1. Clover from which the hay crop was cut June 1, the perfect blossoms showing the absence of the clover-flower midge.

disappeared. Clover cut about this time will not produce heads until after the adults of the spring generation are gone. Heads will be far enough advanced by the 1st of July to escape attack by any of the adults of the summer generation to appear in the fields soon after that time.

SOILING.

To combine clover-seed production with dairying, farmers cut their clover and feed it green during the spring. This practice, known as soiling, affords an effective means of controlling the midge, providing the same precaution; i. e., that the clover be held back sufficiently long to produce heads of the seed crop from developing before the midge appears. In cases where the clover has been cut before it has produced heads, May it may be necessary to cut it a second time in order to accomplish the above result.

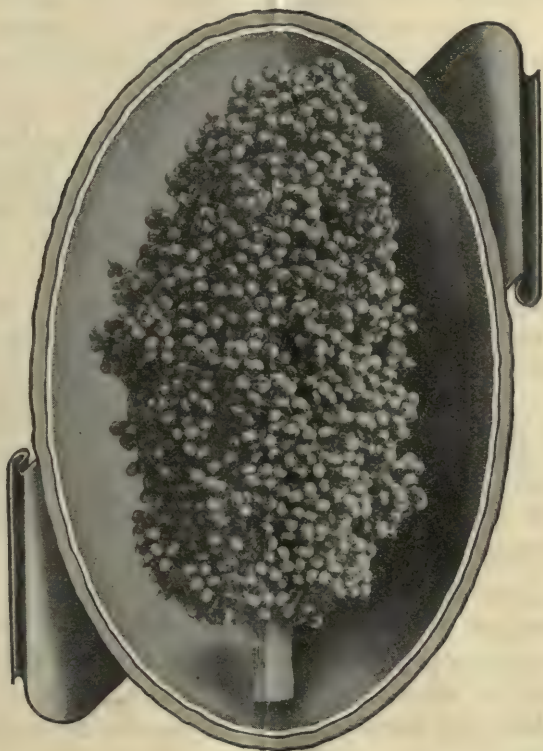
HOW TO USE SORGHUM GRAIN

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Contribution from the Bureau of Plant Industry

WM. A. TAYLOR, Chief

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THE most important groups of grain-producing sorghums are kafir and milo. The grain sorghums are of comparatively recent introduction. They are now extensively grown in the southern half of the Great Plains area.

Sorghum grain is feed for stock and food for man. It also may be used in making alcohol. The grain has about 90 per cent of the feeding value of corn. It is a profitable feed, therefore, when the price is not more than 90 per cent of the price of corn. Where the yield is 10 per cent more than the yield of corn, grain sorghums are as profitable crops to grow as corn.

Sorghum grain is relished by all stock and poultry and if of good quality is readily eaten. For human food the meal can be used in every way that corn meal is used, and the grain may be popped like pop corn.

The thrashed grain should be thoroughly dry and as clean as possible before it is stored in bins. Broken kernels and dirt pack so closely that they exclude the air and so increase the danger of spoiling. Bins for sorghum grain should be equipped with simple and easily made ventilators.

The acreage of grain sorghum is increasing steadily. More of the grain should be used in the section where it is grown.

HOW TO USE SORGHUM GRAIN.

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THE GRAIN SORGHUMS.

THE SORGHUMS first attracted attention because they were drought resistant. When the first wave of settlement swept across the southern Great Plains there was much difficulty in obtaining suitable crops. Corn was found to be well suited to the more humid parts and the more favorable seasons, but in the drier parts of the Plains and in dry seasons it failed.

All members of the sorghum family were found to be very drought resistant; in the favorable seasons they made profitable yields, and in dry seasons they were much better than corn. The grain sorghums, therefore, have come to be extensively used in place of corn for grain production, especially in the drier districts.

The grain sorghums are made up of several different groups of sorghums which produce good yields of feeding grain. Among these groups are kafir, milo, durra (including feterita), and kaoliang. Seeds of these groups are shown in figures 1, 2, and 3. Nearly all of the grain-sorghum crop grown in this country is kafir or milo (see illustration on title-page and figs. 4 and 5).

SORGHUM GRAIN FOR FEED AND FOOD.

The natural uses of sorghum grains are as feed for stock, including poultry; as food for people; and in making industrial alcohol. The value of any feeding stuff or foodstuff depends on at least four

NOTE.—This bulletin is suitable for general distribution in the southern part of the Great Plains area and in California, and to grain dealers, poultry raisers, and alcohol manufacturers anywhere.

factors. The first is the chemical composition, which tells what different substances it contains and how much of each. The second is



FIG. 1.—Seeds of three varieties of grain sorghum. About one and one-quarter times natural size. (A) Milo; (B) Alba (white) milo; (C) feterita.



FIG. 2. Seeds of three varieties of grain sorghum. About one and one-quarter natural size. (D) White durra; (E) durra-kafr hybrid; (F) Blackhull kafr.

digestibility, or how easily or completely these different substances are digested, which may determine how profitably it can be fed. The

third is palatability, or how well it is liked, which may determine how successfully it can be fed. The fourth is preparation and storage, or how readily and safely it can be handled and shipped.

CHEMICAL COMPOSITION OF SORGHUM GRAINS.

The chemical composition of a large number of samples of sorghum grain is shown in Table I. The varieties analyzed were milo, Dwarf milo, feterita, Blackhull kafir, Dawn (dwarf) kafir, Red kafir, and shallu.

TABLE I.—Averages of chemical analyses¹ of air-dry samples of various grain-sorghum varieties grown at the Amarillo Cereal Field Station, Amarillo, Tex., in the eight years, 1908 to 1912 and 1914 to 1916, both inclusive, with the average for each group in all years and the average for 309 analyses in all groups combined in all years, compared with 86 analyses of dent corn.

Varieties.	Number of samples.	Water.	Ash.	Nitrogen.	Protein.	Carbohydrates.	Fat.	Fiber.	Weight per—	
									1,000 kernels.	Bushel.
Milo.....	74	9.30	1.61	2.03	12.65	71.80	3.17	1.48	35.8	58.2
Dwarf milo.....	65	9.32	1.61	1.95	12.33	71.99	3.28	1.48	31.1	58.4
Average of two milos....	139	9.31	1.61	1.99	12.49	71.88	3.22	1.48	33.6	58.3
Feterita.....	15	9.14	1.66	2.26	14.15	70.74	2.92	1.45	32.5	56.2
Blackhull kafir ²	85	9.46	1.78	2.26	14.18	69.38	3.50	1.58	21.5	58.0
Dawn (dwarf) kafir.....	19	9.53	1.67	2.11	13.23	70.69	3.30	1.56	17.1	58.7
Average of two kafirs....	104	9.47	1.76	2.24	14.00	69.62	3.47	1.57	20.7	58.1
Red kafir ²	40	9.49	1.72	1.93	12.04	72.04	3.19	1.51	18.6	58.3
Average of three kafirs...	144	9.47	1.75	2.15	13.46	70.29	3.39	1.56	20.0	58.2
Shallu ³	11	10.16	1.96	2.44	15.23	67.00	3.72	1.92	15.1	57.8
Grand average of all varieties.....	309	9.41	1.69	2.09	13.13	70.91	3.30	1.53	26.6	58.1
Dent corn ⁴	86	10.60	1.50	.....	10.30	70.40	5.00	2.20	.....	.....

¹ The analyses were made by the Plant-Chemical Laboratory of the Bureau of Chemistry, United States Department of Agriculture.

² No grain matured in 1916.

³ Grown only in the years 1911, 1912, and 1914.

⁴ Jenkins and Winton, Compilation of Analyses of American Feeding Stuffs, United States Department of Agriculture, Office of Experiment Stations Bul. 11, 1892.

The average composition of all samples of each variety is shown in Table I. Then the average composition of both milos, of both blackhulled kafirs, and of all three kafirs is given. Finally, the average composition of all varieties in all groups—a total of 309 samples—is presented. There are no striking differences in composition among the varieties grown. In general, they have the same feeding value, so far as analyses show.

The Blackhull kafirs and milos are the staple sorghum crops. When these are directly compared it is seen that the kafirs have more protein and less starch than the milos, with about the same quantities of fat. Red kafir, however, has very nearly the same average composition as the milos. Feterita is a durra closely related to milo. In its slightly higher protein content and lower starch content, how-



FIG. 3.—Seeds of three varieties of grain sorghum. About one and one-quarter times natural size. (G) Red kafir; (H) Mukden (white) kaoliang; (I) Manchu (brown) kaoliang.

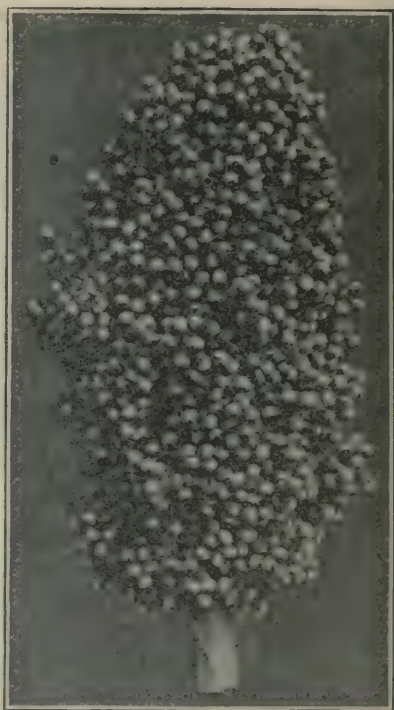


FIG. 4.—Head of milo, about one-half natural size.

ever, it is more like the Blackhull kafirs than it is like milo. Its fat content is lower than that of either milo or kafir. The analyses of shallu are not numerous enough to be conclusive. They seem to show, however, that it is relatively high in protein and fat and comparatively low in starch. They are based on the grain produced in only three years, 1911, 1912, and 1914.

Since the sorghum grains come into direct competition with corn for feeding purposes, the analyses of 86 samples of dent corn are given for comparison. These samples of corn were grown in different years in different States and were analyzed in various places. They are not exactly comparable, therefore, with the analyses of the sorghums, which were all grown at one place and analyzed in one laboratory. However, they probably are fairly representative of the average corn used for feeding purposes and there-

fore may be compared with the analyses of the sorghums. This comparison shows some small differences.

The sorghums are seen to be distinctly higher in protein content than corn. The carbohydrate content is practically the same. The fat content is much lower in the grain sorghums, while the fiber content also is somewhat lower. Since fat in the feeding ration has an effect similar to that of a concentrated carbohydrate, corn may be said to be distinctly richer in carbohydrates, or starchy matter, and the sorghums definitely better in protein content.

DIGESTIBILITY OF SORGHUM GRAINS.

Several experiments have been conducted in the past 18 years to determine the digestibility of sorghum grains, especially kafir. Most of these experiments have been made with stock, chiefly cattle and hogs, but some have used human subjects.

In general, all the results of experiments with animals agree in showing that the starch of the sorghum grains is less digestible than that of corn. It is found that this difference averages about 10 per cent. In other words, the sorghum grains have about 90 per cent of the feeding value of corn. In the early experiments a difference considerably greater than 10 per cent sometimes was recorded. Later experiments tend to show that the difference really is not so large as this figure.

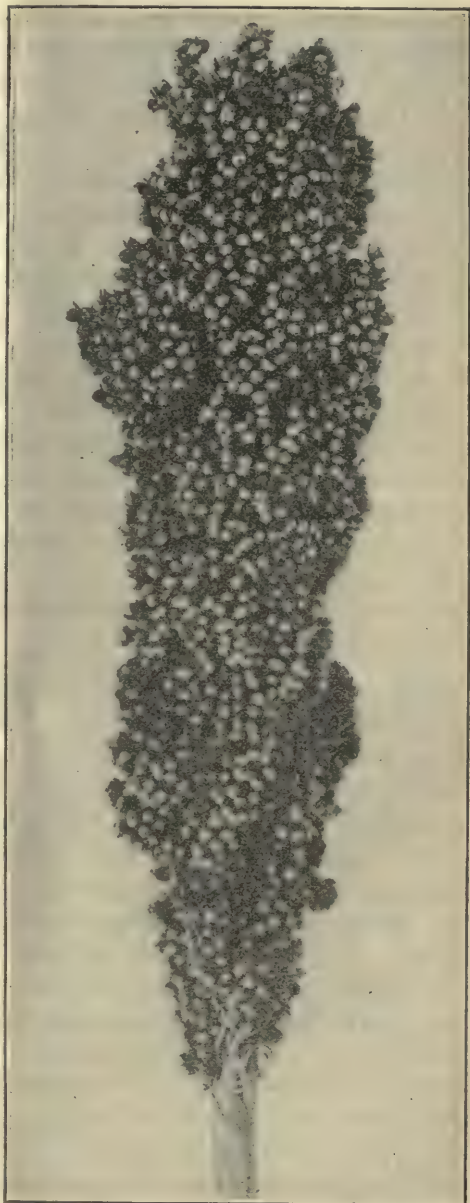


FIG. 5.—Head of Blackhull kafir, about one-half natural size.

Let 10 per cent be allowed as a fair average of the difference in value. The grain sorghums still are profitable feeding grains when the price is not more than 90 per cent of the price of corn of the same grade.

The experiments to determine the digestibility of sorghum grains when fed to human beings have been made by the Office of Home Economics of the Department of Agriculture. They show that from 96 to 98 per cent of the starch was digested. This is practically the same percentage as in the case of corn. In these same experiments a considerably smaller percentage of the protein of the sorghums than of corn was digested. The total protein content of the sorghum grains is considerably larger than that of corn. Therefore, the total quantity of protein digested from a pound of sorghum grain may be fully as large as the quantity digested from a pound of corn, although the percentage digested is smaller.

If the farmer growing kafir or milo is at a disadvantage in the relative value of his grain he has several advantages in compensation. His crop is grown on cheaper land. He is close to the source of cottonseed meal as a protein concentrate for his feeding ration. If he is himself the feeder, his stock are fed under milder winter conditions than those of the corn-belt feeder.

PALATABILITY OF SORGHUM GRAINS.

There seems little need for discussion of the palatability of the sorghum grains. Stock and poultry of all kinds eat them readily when they are of good quality. Moldy or wormy heads or musty and weeviled grain will not be palatable, any more than corn, oats, or barley in the same condition. Owing to the hardness of the kernels it is always desirable to grind or chop them for feeding.

For human food the meal of these grains has a distinctive and agreeable flavor. Some persons think the flavor resembles that of buckwheat flour more than it does the flavor of corn meal or wheat flour. The best methods of preparing these meals for the table should be studied, since no food is palatable unless well cooked. See the list of publications at the end of this bulletin.

PREPARATION AND STORAGE OF SORGHUM GRAINS.

PREPARATION.

The grain-sorghum crop is harvested in three general ways. It is cut and bound with the corn binder, or headed with the kafir header, or ordinary grain header, or it is headed by hand.

That which is bound may be fed in the bundle or shocked and headed later in the season or as needed. Grain sorghums are fed in

the bundle usually only as a maintenance ration for horses not at work or for cattle not producing milk or not being fattened for market.

One problem in the handling of grain sorghum when the crop is headed is the proper curing and storage of the heads. Usually these heads are thrown out in long, shallow piles to cure, especially if the crop is at all green or if it is wet from recent rains. This is a satisfactory way of curing in favorable weather, if the piles are not made too large.

If the crop is fully mature and thoroughly dry the heads may be hauled direct to a well-ventilated granary or crib. This can be done more safely in the case of milo and feterita than with kafir. The kafir heads (fig. 5) are more slender, and the straight stem is still green and somewhat juicy when the grain is ripe. This crop is more likely to heat, therefore, when piled in quantity. The short, broad heads of milo (fig. 4), with their somewhat crooked stems, do not pack so tightly together.

Headed kafir or milo may be sold or fed in the head, or the heads may be ground into head chops, or they may be thrashed and only the grain used. The thrashed grain should never be fed whole to stock, but always crushed or ground coarsely, in which form it is known as kafir or milo chops.

The grain should be allowed to become thoroughly dry, if possible, before thrashing or grinding. In ordinary thrashing a high percentage of the grain is cracked. Cracked grain packs more closely and spoils more readily than whole grain. Great care should be taken to crack as little as possible in thrashing. The proportion of cracked kernels can be much decreased by reducing the speed of the cylinder or by removing part of the concaves.

STORAGE.

One of the principal problems in connection with the use of sorghum grains is the storage of the heads or thrashed grain or chops. Like corn, they may get out of condition in the crib or bin and become damaged if special care is not taken. Excessive moisture content probably is the most common cause of damage. The average moisture content of sorghum grain is not as high as that of corn. This is due partly to the smaller size of the kernel and partly, perhaps, to its being produced in dry districts. Nevertheless, when the water content is above normal the grain will heat readily if not carefully handled. The grain should be thoroughly dry before being stored in bins, and it should be watched while storage continues.

Bins used in storing sorghum grains should be well ventilated. Free circulation of air through the mass of grain is the best insur-

ance against heating. Some principles which affect the storage of these grains are stated briefly below :

(1) The more moisture the grain contains when put in storage, the more readily it will heat.

(2) The larger the quantity stored in a single bin, the greater the risk of damage by heating.

(3) The warmer and damper the climate, the quicker the grain will get out of condition.

(4) The more cracked kernels and dirt the grain contains, the closer it packs, the less the air can circulate, and the greater the danger of loss.

(5) Weevils working in grain increase its temperature and decrease the spaces for air circulation, thus making conditions favorable for further damage from heating.

In elevators it usually is possible to prevent damage from heating when it first starts by running the grain from one bin to another. In this way it is aired and cooled. This shifting of the grain must be repeated whenever rising temperature in the grain makes it necessary.

Most farms are not equipped with machinery for handling grain. The farm bin, therefore, should be provided with ventilators if these grains are to be stored. Different kinds of ventilating devices have been described. Of these, only one of the most practical is described and illustrated in this bulletin.

The simplest and cheapest ventilator was devised by Mr. George Bishop and fully described by him in the issues of the Oklahoma Farm Journal during the autumn of 1915. The following description is adapted from that source.

This ventilator (fig. 6) is a long, narrow box of wood and wire screen, extending from side to side of the bin and opening to the outer air. To make it, take two pieces of 1-inch board (*a*) 4 inches wide and as long as the bin is wide. Place these on edge about 4 inches apart. Take cleats or strips of wood (*b*) 1 inch thick and 1½ or 2 inches wide, and mortise them into the upper edges of the boards (*a*), flush with the surface and about 1 foot apart.

Take galvanized wire screen, either ordinary fly screen or similar screen with a mesh too small to permit kafir seeds to pass through. Cover the ends of the ventilator with pieces of screen (*c*) cut large enough to lap over on to the sides for an inch or so and tack tightly. Then cut the screen into strips wide enough (about 19 or 20 inches) to go completely around the ventilator box. Fasten all the screen (*d*) tightly with tacks or small staples.

The ventilator now has two wooden sides and a wire screen top, bottom, and ends. Across the bottom, nail several cleats (*e*) or strips of 1-inch lumber. These will lift the ventilator an inch from the floor and permit air to circulate freely in the lowermost layer of grain.

These ventilators should be placed 3 or 4 feet apart on the floor of the bin. The ends should fit into or set flush against holes cut in the outer walls of the bin. The joining of the ventilator and the hole should be made grain tight by strips of wood if necessary. If the grain begins to heat, the hot air rises and cold air is drawn in from

below through the ventilator and upward through the mass of grain, which is cooled thereby. The wire screen across the ends of the ventilator prevents the entrance of rats and mice. When the bin is

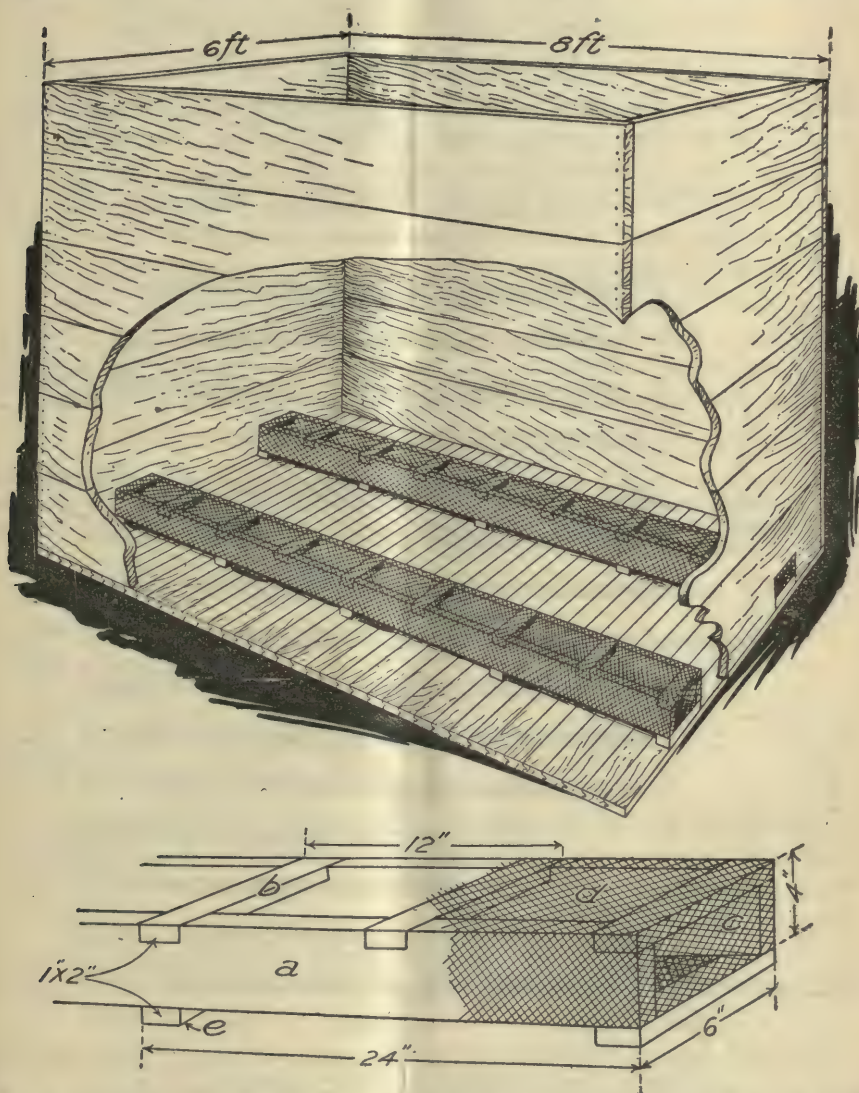


FIG. 6.—Ventilator for a bin containing sorghum grain. Upper figure, view of two ventilators in position on floor of bin, showing opening in side of bin. Lower figure, detailed structure and dimensions: (a) Side of ventilator; (b) cleat mortised in upper edge of a; (c) wire screen over end of ventilator; (d) wire screen covering top and bottom, also sides; (e) cleat on bottom to raise ventilator from floor.

not in use, the ventilators should be removed and placed where the wire screen will not be broken.

In wide and deep bins, it may be desirable to place a row of upright ventilators through the middle of the bin. The lower screen-

covered end should rest on the horizontal ventilator, thus making a sort of chimney up through the mass of grain and giving still better circulation of air.

ACREAGE AND VALUE OF GRAIN SORGHUMS.

A very large acreage of grain sorghums is grown in the States of Kansas, Oklahoma, and Texas. Smaller areas are raised in Colorado, New Mexico, Arizona, and California. The Bureau of Crop Estimates has published figures showing the estimated acreage and production of these crops during the last three years in the first six States named above. These figures are shown in Table II, together with the farm price per bushel on December 1 of each year.

The small reduction in acreage in 1916 was due in part to the very low price obtained for the very large crop of 1915. The large increase in acreage in 1917 was caused partly by the necessity of growing spring-sown crops on large areas where winter wheat was killed.

TABLE II.—*Acreage, average acre yield, total production, and farm value per bushel and total value, on December 1, of grain sorghums grown in the States of Kansas, Oklahoma, Texas, Colorado, New Mexico, and Arizona in the three years from 1915 to 1917, inclusive.*

Year.	Acreage.	Production (bushels).		Farm value on Dec. 1.	
		Per acre.	Total.	Per bushel.	Total.
1915.....	4,153,000	27.6	114,460,000	\$0.45	\$51,157,000
1916.....	3,812,000	13.2	50,340,000	1.06	53,269,000
1917.....	4,894,000	14.7	75,866,000	1.61	121,842,000

Kansas was one of the first States to grow grain sorghums extensively and is now one of the three States leading in their production. For many years the Kansas State Board of Agriculture has published annual statistics of crop production and value. In figure 7 are given the comparative acreages of grain sorghums and corn in Kansas in the 15 years from 1903 to 1917, inclusive, taken from these reports.

This illustration shows the steady increase of corn acreage to 1910 and a considerable decrease for 5 years thereafter. At the same time, there was a considerable increase in the acreage of grain sorghums in the three years from 1911 to 1913, inclusive. This was due to dry seasons in which the superiority of these crops over corn was clearly demonstrated. In 1915, extraordinarily high yields on a large acreage resulted in a bumper crop of grain sorghums. The price, however, was very low, due to enormous production and the fact that much of it was thrown directly on the market instead of being fed where grown. This low price tended to reduce the acreage

somewhat in 1916. Owing to the winterkilling of millions of acres of wheat in Kansas and Oklahoma in the winter of 1916-17, there was a very large increase in the acreage of grain sorghums in 1917. The area sown was the largest ever known in Kansas.

INCREASING THE USE OF SORGHUM GRAINS.

As already shown, the acreage devoted to grain-sorghum crops has grown rapidly in recent years. In the early years of production the

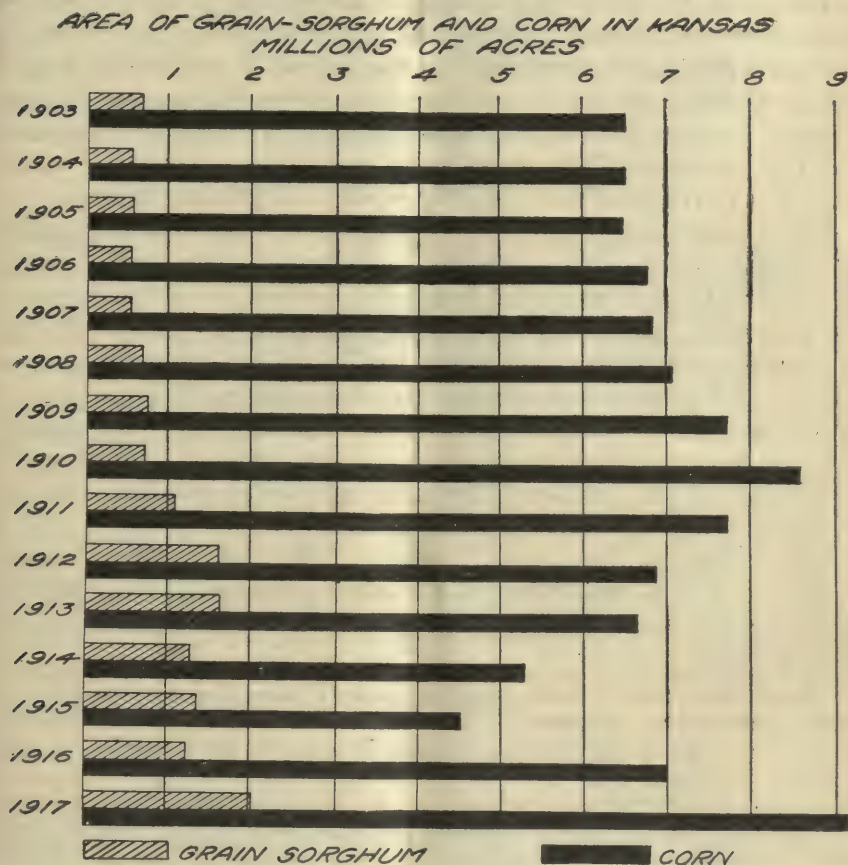


FIG. 7.—Diagram showing the comparative acreage of grain sorghum and of corn in Kansas during the 15 years from 1903 to 1917, inclusive.

crop was wholly used on the farms where it was grown. As the merits of these crops became better known and the acreage increased, there has been a growing surplus to dispose of commercially. There has always been some difficulty in marketing this surplus promptly at profitable prices.

The value of sorghum grain for feeding in beef, milk, pork, and egg production and for human food is not yet fully recognized. In some seasons of large production the grain has been almost a drug on

the market during the fall. In the following spring, however, the price has increased as the increasing price of feeding corn turned the attention of feeders toward it. If it is to be in any sense the money crop of certain districts it must be readily and profitably convertible into cash. This means that the surplus must be able to move freely at good prices soon after being thrashed.

SORGHUM GRAIN FOR FEEDING STOCK.

The chief use for sorghum grain is as feed for various classes of stock, including horses, cattle, sheep, swine, and poultry. Since it is a feeding grain, it is reasonable to believe that it can be fed as profitably where it is grown as elsewhere, other things being equal. Freight charges on the crop shipments are avoided thereby, as is also the wagon haul from farm to railroad. It is much more readily and cheaply transported to market in the form of beef or pork.

These crops have been grown in the midst of the greatest stock-producing section of the country, and yet most of the grain has not been fed in the section where it and the stock are grown. To reverse the statement, both cattle for feeding and grain sorghums for feed are raised extensively in the southern Plains area, but the cattle are shipped out to be fed elsewhere. In stock feeding lies the greatest opportunity for expansion in the use of sorghum grain. It is realized that the financing of extensive stock-feeding operations is a slow and somewhat difficult matter. The start has been made, however, and progress should be aided and encouraged.

The feeding of these grains has been fully discussed in Farmers' Bulletin No. 724, from which the following general facts are taken. For suggested rations and results obtained the reader should consult the bulletin.

Horses, mules, cattle, sheep, hogs, and poultry have been fed the grains of these nonsaccharine sorghums with very satisfactory results. Breeding animals or those which are working or being fattened for the block eat properly prepared sorghum grains with much relish. However, as the grains are small and rather hard, grinding or crushing is recommended before feeding, except for sheep and poultry. Sheep masticate the small kernels well, thus rendering them readily accessible to the digestive juices, while poultry feed upon the unbroken grain, which is especially palatable to them in this form. If the grain is not ground for other stock it is less palatable and much of it passes through the digestive tract unbroken; thus much of the total feeding value is lost.

Very often the entire heads are ground up, producing a feed of greater bulk. The resulting meal, called head chop, resembles corn-and-cob meal in food value. It is recommended especially where the supply of roughage is limited, and usually is economical for feeding stock not being finished for market. Head chop is valuable in producing a high finish when supplemented by a rich concentrate such as cottonseed meal.

The quantities to be fed to the different kinds of animals depend upon many factors, such as the amount and kind of roughage and of other con-

centrates available, the age, type, and size of the animals, and for what purpose the stock is being fed. Rations for various classes of stock are hereinafter suggested.

The feeder always should remember that sorghum grains alone do not form a balanced ration, and the same care which is exercised in feeding corn should be applied when feeding grains of the sorghums. This applies with particular emphasis to the rations for young and growing stock. Some feed which is rich in protein must also be given if favorable results are to follow heavy feeding of this class of grains.

The increasing number of silos in the States of the southern Great Plains area will be a direct aid to cattle-feeding operations. The combination of home-grown silage and feeding grain, with readily accessible cottonseed meal, ought to aid in making feeding profitable in the grain-sorghum belt.

SORGHUM GRAIN FOR FEEDING POULTRY.

The sorghum grains, especially Blackhull kafir (see fig. 2), are excellently adapted for poultry feed. In size they are small enough so that they are readily fed without cracking or crushing. It probably is a safe estimate that kafir or other grain-sorghum seed forms fully 25 per cent of the prepared poultry feed sold in this country. It is used mostly in mixture with other grains, such as corn, wheat, and screenings.

There is a steady demand for these grains in the manufacture of poultry feed. When the crop in this country has been short, as in 1909, similar varieties have been imported from as far away as India and China. The poultry industry is increasing steadily in this country. It is probable that kafir grain would form a still larger proportion of the total poultry feed manufactured if it were always available at satisfactory prices. This avenue for extending the use of these grains should not be neglected.

SORGHUM GRAIN FOR HUMAN FOOD.

Ever since grain-sorghum crops were first grown in the dry-land West they have been used to some extent for human food. Ground at the local gristmill, they have been turned into batter cakes in the farm kitchen on many a winter's morn. In the making of corn bread or johnnycake they have taken the place of corn meal with satisfaction to the consumer. The grain also may be used successfully for pop corn.

Only in recent years, however, have scientific tests been made to determine their value in the human diet. The results of these experiments show that the meal of kafir and milo is comparable with corn meal. It can be used alone or in mixture with wheat flour in varying proportions in such ways as corn meal is used.

Owing to the absence of gluten in the protein, grain-sorghum flour can not be used alone for making raised bread. It should not be ground into flour, therefore, but into meal instead. In this form it can be used for pancakes, bread, mush, puddings, etc., just as corn meal is used.

The use of kafir as human food has been discussed in Farmers' Bulletin 559. The following statements concerning it are quoted from that bulletin:

Since kafir resembles corn closely in composition and nutritive value, it is unnecessary to treat of these subjects in detail here. Something, however, must be said about special precautions necessary in preparing it for the table. In making mush for use alone, or as a foundation for other dishes (yeast bread, gingerbread, etc.), the ingredients should be thoroughly mixed before being heated. Cooking should always be more thorough than for Indian corn. In making gingerbread with corn meal, for example, it has been found sufficient to heat the meal and water for 10 minutes in a double boiler; but in making the same dish with kafir meal it is necessary to cook the mush at least half an hour.

SORGHUM GRAIN FOR MAKING ALCOHOL.

The principal material from which alcohol is produced is starch. The demand for industrial alcohol was increasing rapidly even before the outbreak of the war. During the continuation of the war the demand for alcohol in munitions manufacture is expected to be enormous. The sorghum grains, with their 70 per cent or more of starch, are excellent alcohol producers. Following the production of a bumper crop of grain sorghums in 1915, considerable quantities of sorghum grain were used in making alcohol. The location of factories in the producing area would do much to promote a larger use for this purpose.

FOREIGN MARKETS FOR SORGHUM GRAIN.

One other factor in the situation should not be overlooked. This is the possibility of developing a larger export trade in these grains. Occasional cargoes have left Galveston or New Orleans for European ports. Very little has been done, however, to stimulate this line of trade expansion. There is some difficulty in keeping these grains from heating during ocean voyages, especially in hot weather. It is probable, however, that means can be found to overcome this difficulty, along the lines already discussed in the paragraphs on storage.

Investigations have been conducted in Germany to determine the feeding value of grains very similar to these. It will be remembered that most of the grain sorghums are of African origin. Various sorghum crops were grown extensively in the German East African

colonies. The investigations in Germany were started in connection with the development of this industry in those colonies.

European countries are importers of enormous quantities of American feeding grains. This is likely to continue in spite of colonial developments of this kind. If the facts concerning the value and profitable use of American grain sorghums can be brought to the attention of exporters here and importers abroad, a considerable demand for these crops ought readily to result. Fortunately, the States producing sorghum grains are fairly well situated for getting the crop to the Gulf coast for ocean shipment.

PUBLICATIONS ON GRAIN SORGHUMS.

In the list that follows, those publications to which no price is attached may be obtained without charge upon application to the Secretary of Agriculture; publications having a price attached may be obtained by remitting the stated sum to the Superintendent of Documents, Government Printing Office, Washington, D. C.

UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

FARMERS' BULLETINS.

Milo as a Dry-Land Grain Crop. Farmers' Bulletin 322. Price, 5 cents.
Better Grain-Sorghum Crops. Farmers' Bulletin 448. Price, 5 cents.
Kafir as a Grain Crop. Farmers' Bulletin 552.
Use of Corn, Kafir, and Cowpeas in the Home. Farmers' Bulletin 559.
The Feeding of Grain Sorghums to Live Stock. Farmers' Bulletin 724.
Cereal Crops in the Panhandle of Texas. Farmers' Bulletin 738.
Shallu, or "Egyptian Wheat." Farmers' Bulletin 827.

DEPARTMENT BULLETINS.

Corn, Milo, and Kafir in the Southern Great Plains Area: Relation of Cultural Methods to Production. Department Bulletin 242. Price, 5 cents.
Studies on the Digestibility of the Grain Sorghums. Department Bulletin 470.

BUREAU OF PLANT INDUSTRY CIRCULARS.

Feterita, a New Variety of Sorghum. Bureau of Plant Industry Circ. 122-C.
Price, 5 cents.
Three Much-Misrepresented Sorghums. Bureau of Plant Industry Circ. 50.
Price, 5 cents.

BUREAU OF PLANT INDUSTRY BULLETINS.

The History and Distribution of Sorghum. Bureau of Plant Industry Bulletin 175. Price, 10 cents.
The Importance and Improvement of the Grain Sorghums. Bureau of Plant Industry Bulletin 203. Price, 10 cents.
Grain-Sorghum Production in the San Antonio Region of Texas. Bureau of Plant Industry Bulletin 237. Price, 5 cents.

The Kaoliangs: A New Group of Grain Sorghums. Bureau of Plant Industry Bulletin 253. Price, 15 cents.

Cereal Experiments in the Texas Panhandle. Bureau of Plant Industry Bulletin 283. Price, 10 cents.

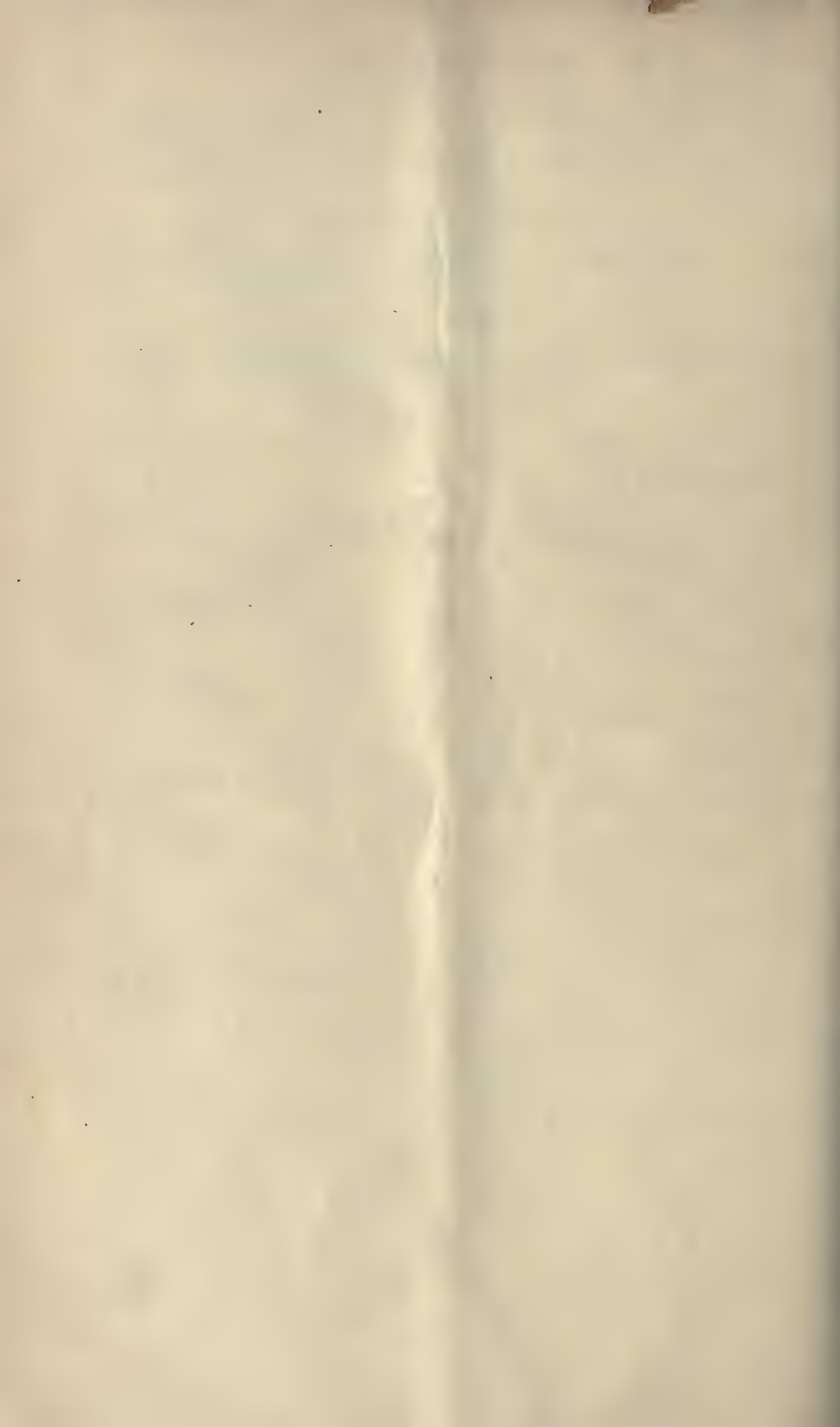
BUREAU OF CHEMISTRY BULLETIN.

The Feeding Value of Cereals as Calculated from Chemical Analyses. Bureau of Chemistry Bulletin 120. Price, 10 cents.

YEARBOOK SEPARATE.

The Grain Sorghums: Immigrant Crops That Have Made Good. Yearbook (1913) Separate 625. Price, 5 cents.





2-2

THE SOY BEAN: ITS CULTURE AND USES

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FARMERS' BULLETIN 973

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry

WM. A. TAYLOR, Chief

Washington, D. C.

July, 1918

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THE EXTENSIVE UTILIZATION of the soy bean for forage and the increased use of the beans for oil and for human food have resulted in an enormous increase in the acreage of the crop.

The climatic adaptations of the soy bean are about the same as those of corn. It is more drought resistant and less sensitive to an excess of moisture than cowpeas and corn. The soy bean succeeds best on fertile sandy loams and clay loams.

When sown on land not previously planted to this crop, it is advisable to inoculate it.

The best time for planting soy beans is about that for planting corn.

The variety to plant is of prime importance and should be one adapted to local conditions. About 20 varieties are now handled by growers and seedsmen.

Soy beans may be combined in many systems of crop rotations, their cash value being sufficient to encourage the growing of the beans as one of the main crops.

In combination with other crops, such as corn, cowpeas, and Sudan grass, the soy bean furnishes a well-balanced ration, a large yield, and a great variety of forage.

The large yield of seed, the ease of harvesting it, and the increasing demand for the beans for planting purposes, for food, and for the production of oil and meal recommend the soy bean for seed production.

The feeding value of soy-bean seed compares favorably with that of other concentrated feeds. The growing of seed for feeding will produce, at a moderate cost, at least part of the high protein concentrates necessary for stock feeding and milk production.

The straw obtained from thrashing soy beans for seed is a valuable feed for all kinds of stock.

The variety and palatability of the forms in which the soy bean can be served make it a very desirable article of human food, and its use as such is gradually increasing.

The soy bean makes an excellent hay of high feeding value which is greatly relished by all farm animals. From 1 to 3 tons of hay to the acre, and occasionally 4 tons, are obtained.

As a pasture crop the soy bean can be used to advantage for all kinds of stock. The most profitable method is to pasture with hogs, supplementing the corn ration. Mixed with corn, the soy bean is excellent for ensilage.

No insect or fungous pest has assumed any great economic importance in the culture of the crop. The soy bean, however, is subject to root-knot, a disease caused by an eelworm, or nematode, which occurs in many of the lighter soils of the South. To plant soy beans on such infested soil is a dangerous practice.

THE SOY BEAN: ITS CULTURE AND USES.

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COMMERCIAL IMPORTANCE.

THE SOY BEAN (fig. 1), also called the soya bean, the soja bean, and in North Carolina the stock pea, is an annual leguminous plant, a native of southeastern Asia. It has been cultivated in China, India, and Japan for more than 5,000 years and in extent of uses and value is the most important legume now grown in these countries. Within the past few years the soy bean has become a crop of special importance in the world's commerce, and large shipments of beans, oil, and meal have been made from Manchuria to America and European countries. The soy bean, which is very rich in protein, is largely utilized by Asiatic people for food, a great variety of products being prepared from it. As the bean contains a valuable vegetable oil, it is also extensively employed in the production of oil and cake.

The soy bean was introduced into the United States as early as 1804, but it is only during the last decade that it has become a crop of much importance. At the present time it is most largely grown for forage. In many sections, especially southward and in some parts of the corn belt, a very profitable industry has developed from the growing of seed. During the past few years the acreage has increased to a very considerable extent. The large yield of seed, the excellent quality of forage, the ease of growing and harvesting the crop, its freedom from insect enemies and plant diseases, and the possibilities of the seed for the production of oil and meal and as a food all tend to give this crop a high potential importance and assure its greater agricultural development in America (fig. 2).

CLIMATIC ADAPTATIONS.

In general the climatic adaptations of the soy bean are about the same as those of corn (fig. 3). The soy bean is especially adapted to the cotton region of the United States and northward to the Ohio

and Potomac Rivers, in which latter region the larger and later varieties, which give yields that make their extensive cultivation very profitable, can be grown. Recent introductions of early-maturing varieties from northern Manchuria mature profitable yields of seed in the northern tier of States, while the later varieties can be grown

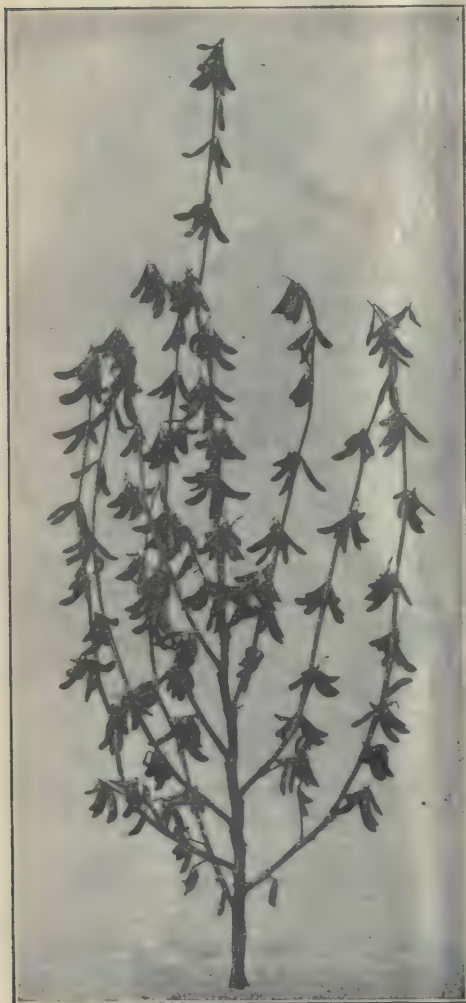


FIG. 1.—A typical mature soy-bean plant.

successfully for hay or ensilage. Under the conditions in the extreme southern parts of the Gulf States the soy bean seldom behaves normally. Although a satisfactory growth of forage is obtained, the pods often do not fill. Similar conditions exist in the Southwest, where extremely hot weather prevails during the period when the pods are maturing. Under irrigation, soy beans have given good results in many sections.

The soy bean is more drought resistant and also less sensitive to an excess of moisture than either cowpeas or corn. Rabbits are exceedingly fond of the plant, and but for the depredations of these animals the soy bean would be a valuable crop in the semiarid West.

SOIL REQUIREMENTS.

Although the soy bean will succeed on nearly all types of soil, the best results are obtained on mellow, fertile

sandy loams or clay loams. In general, the soil requirements of the soy bean may be said to be about the same as those of corn, although soy beans will make a more satisfactory growth on poorer soil than corn, provided inoculation is present, but they will not make nearly as good growth on poor soil as cowpeas. Practical experience indicates that the cowpea succeeds better than the soy bean on the heavier clays and on the lighter sandy soils. With inoculation and moderate

quantities of fertilizer the soy bean thrives well on the sandy soils of the Coastal Plains area. On the vegetable-mold soils of eastern North Carolina excellent yields of beans and forage are obtained, and the crop occupies an important place in the farming systems of this region.

The soy bean does not require a well-drained soil for its best development, although it will not succeed where water stands for any considerable length of time. Swamp and peat soils after being drained and limed have usually been found to produce this crop very well. Soy beans will thrive on soils that are too acid for the successful culture of red clover.

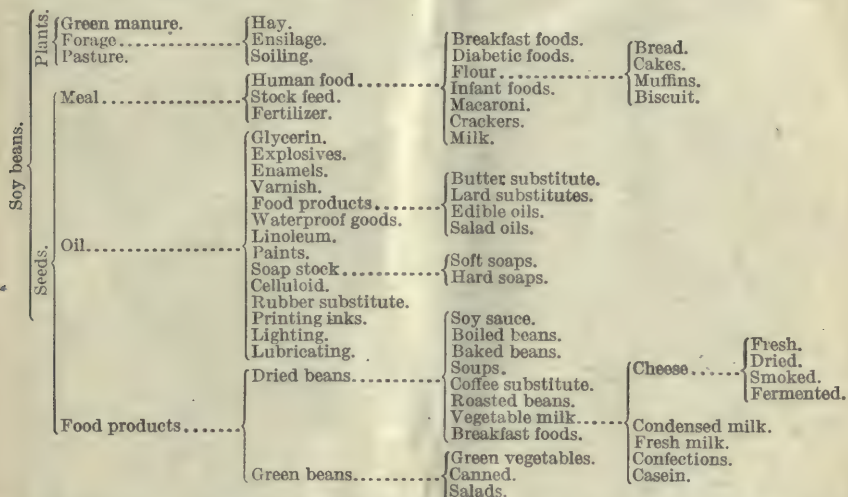


FIG. 2.—Diagram showing the various ways in which the plants and seeds of soy beans are utilized.

PREPARATION OF THE SEED BED.

The preparation of the soil for the soy bean is similar to that for corn, and it, like corn, readily responds to any extra preparation. The land should be plowed early and deep, fitted, and then harrowed at intervals until the beans are planted; otherwise, weeds are likely to choke out the young plants. Disking will give the proper preparation after a crop of early potatoes or peas or for stubble land after wheat or winter oats, provided the soil is moist and mellow. A firm seed bed with a light, loose covering of fine soil, well smoothed by the harrow, is conducive to uniform depth in planting and to a good stand of plants. A soil free from clods insures the best results, especially in seeding broadcast, which may be desirable on the better types of soil.

FERTILIZERS.

When grown on land giving good yields of corn or following corn, as it frequently does, a good crop of soy beans should be produced without direct applications of fertilizers. The use of fertilizers is

recommended, however, where sandy soil predominates or the soil is of low fertility. The application of nitrogenous fertilizers is not necessary, as the soy bean, like other legumes, assimilates the free nitrogen of the air. All fertilizer tests that have been conducted with this crop indicate that the best results, where fertilizers are required, are obtained with stable manure or about 300 pounds of acid phosphate and 250 pounds of wood ashes or 25 pounds of muriate of potash. Where neither the wood ashes nor the potash can be obtained, the acid phosphate may be used alone to good advantage. In using commercial fertilizers it is advisable to work them well into the



FIG. 3.—Outline map of the United States, showing the areas to which the soy bean is especially adapted, as to varieties and purpose: 1, The later and larger varieties, for seed production; 2, medium and medium-late varieties for seed and the same varieties and later varieties for forage; 3, very early varieties for grain production and the medium and medium-late varieties for forage and ensilage.

soil before planting. The application of lime has been found invariably to increase the yield of soy beans, though they are not as sensitive to lime as red clover, alfalfa, and many other crops.

INOCULATION.

Like other legumes, the soy bean is able to utilize the nitrogen of the air through the action of bacteria which live on the roots of the plant. The presence of these organisms is indicated by the development of nodules or tubercles on the roots (fig. 4). Soy beans will make an indifferent growth in most soils (fig. 5) unless the bacteria are present in the soil. The lack of inoculation is generally indicated by a pale or greenish yellow color of the plant. The soy bean will give very good results, however, on rich soils, even though the bacteria are not present, but in such cases the nitrogen is taken directly from the soil.

Natural inoculation now occurs quite generally throughout much of the area where soy beans are grown extensively. When sown on land which has not been previously planted to this crop, however, it

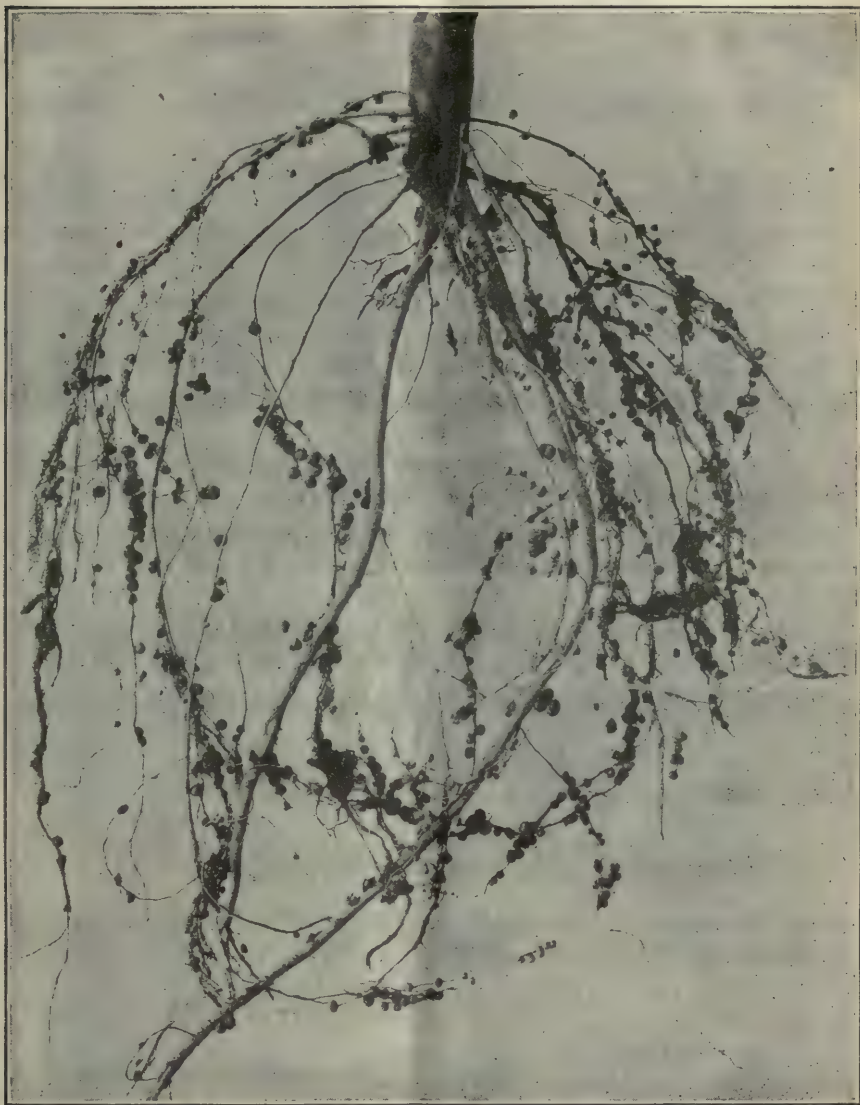


FIG. 4.—Roots of a soy-bean plant, showing abundant development of nodules.

is advisable to inoculate with the proper culture. Inoculation may be obtained either through the use of a pure culture, a limited quantity of which can be procured from the United States Department of Agriculture free of charge, or by the use of inoculated soil from a field where soy-bean plants have previously developed nodules. The inoculated soil may be drilled in at the time of seeding, using the fer-

tilizer box, or by thoroughly mixing a gallon of the soil to a bushel of seed.

Numerous investigations have been carried on relative to the influence of inoculation on the growth and composition of the soy bean. The Michigan Agricultural Experiment Station¹ found that although the presence of the bacteria on the roots in a fairly fertile soil did not notably increase the yield, the inoculated plants were far richer in protein and therefore of greater value than the ones not inoculated. Results obtained by the Wisconsin station² indicate that inoculation of the soil is beneficial by increasing the nitrogen content of the plant, the percentage of fertilizer ingredients in the roots, and the protein



FIG. 5.—A plat of soy beans without inoculation (in the foreground) and an adjacent plat which had been inoculated (in the background).

content of the beans. At the New Hampshire station³ an inoculated plat of soy beans gave 7.2 tons in green weight to the acre, while an uninoculated plat gave 4.7 tons. Analyses of seeds of inoculated plants at the Timothy Breeding Station in Ohio showed 42.47 per cent protein and for seeds of plants not inoculated, 35.26 per cent protein.

TIME OF PLANTING.

Soy beans may be sown during a period extending from early spring until midsummer, depending largely on the latitude and the

¹ Smith, C. D., and Robinson, F. W. Observations on the influence of nodules on the roots upon the composition of soy beans and cowpeas. Mich. Agr. Exp. Sta. Bul. 224, p. 127-132. 1905.

² Woll, F. W., and Olson, G. A. The effect of soil inoculation on the distribution of the fertilizer ingredients in soy beans. In Wis. Agr. Exp. Sta., 24th Ann. Rpt., [1906]/07, p. 164-166. 1907.

³ Prince, F. S. The soy bean in New Hampshire. N. H. Agr. Exp. Sta. Bul. 181, 20 p., 6 fig. 1917.

use to be made of the crop. For grain or as a main hay crop, the best time is about that for planting corn, when the ground has become thoroughly warm. The plants will then start quickly and make a rapid growth. In general, early plantings require more days to mature than late plantings, the difference in the same variety often amounting to three weeks or more. The plants grow slowly in cool weather, and ordinarily there is no advantage in planting earlier than corn, especially the late varieties. As a pasture, green-manure, soiling, or even as a hay crop, the soy bean may be sown as late as August 1 in the South and as late as July 1 in the North.

The extreme dates of successful planting at the Tennessee Agricultural Experiment Station were found to be April 3 and August 6, although June proved to be the most favorable month in which to plant any variety. Similar results were obtained with a large number of varieties planted at 2-week intervals beginning May 1 and extending to August 1 at Arlington Farm, Va. The yields of forage and seed secured from different dates of planting with the Haberlandt variety at Arlington Farm are shown in Table I.

TABLE I.—*Acre yield of forage and seed of the Haberlandt variety of soy beans in date-of-planting tests at Arlington Farm, Va.*

Date of planting.	Green forage.	Dry forage.	Seed.	Date of planting.	Green forage.	Dry forage.	Seed.
	<i>Tons.</i>	<i>Tons.</i>	<i>Bushels.</i>		<i>Tons.</i>	<i>Tons.</i>	<i>Bushels.</i>
May 1.....	8.92	2.09	33.3	July 1.....	7.18	2.00	24.3
May 15.....	10.06	2.39	34.0	July 15.....	6.18	1.50	19.3
June 1.....	8.55	1.90	33.3	August 1.....	2.63	.87	(1)
June 15.....	7.54	1.83	25.3				

The planting of August 1 did not mature.

DEPTH OF PLANTING.

The depth of planting is of much importance, as poor stands frequently result from too deep covering. In the heavier types of soil shallow plantings, about 1 inch, tend to lessen the chance of failure due to the formation of a soil crust after heavy rains. In sandy soils or light loams the planting may be deeper, but should not exceed 3 inches. If the seed is planted during a dry period, 3 inches will not be too deep. In case of a rain, a smoothing harrow or weeder may be employed to break any crust which may form on the surface. Under usual spring conditions, comparatively shallow plantings will give the best results.

RATE OF SEEDING.

The quantity of seed to be sown to the acre will necessarily vary somewhat, according to the size of the seed and the purpose for which the crop is grown. The different varieties of soy beans vary widely in size of seed, as shown in figure 6. With rows 24 to 40

inches apart, about 30 pounds of medium-sized seed will be required to the acre. Where sown broadcast for hay, green manuring, ensilage, or soiling, about 90 pounds of medium-sized seed to the acre will be ample. At the Ohio Agricultural Experiment Station¹ in a

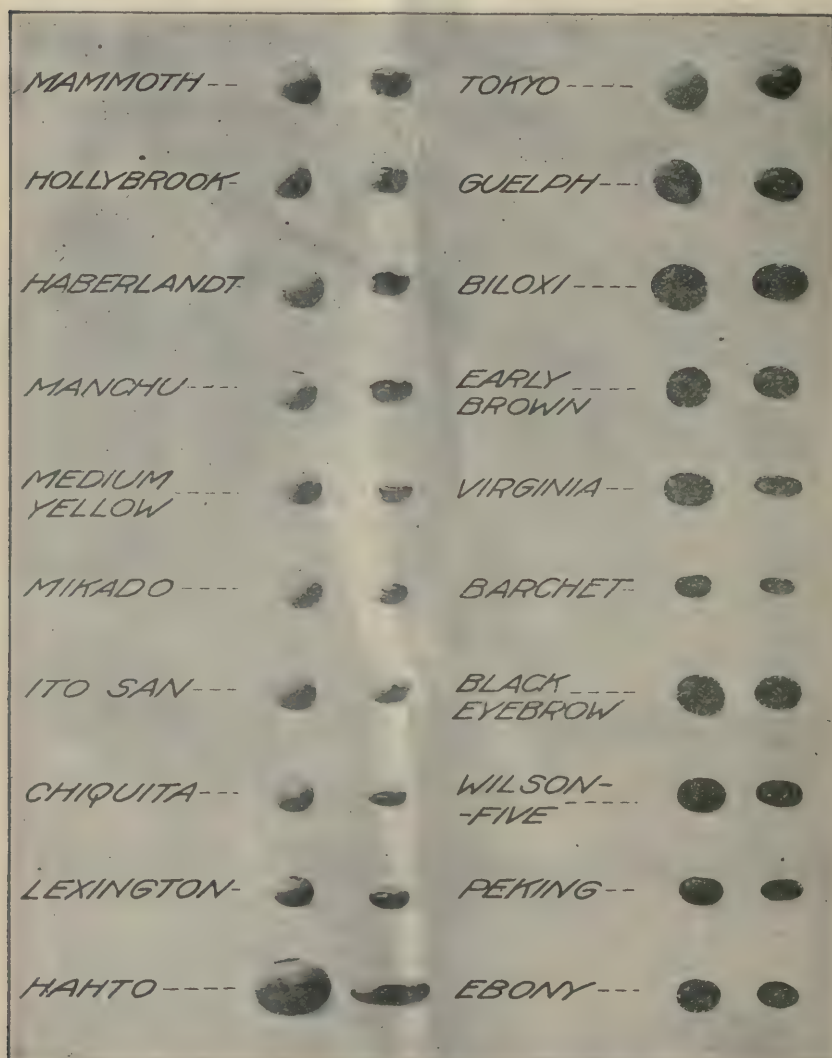


FIG. 6.—Seeds of the most important varieties of soy beans.

3-year method and rate of seeding test, 45 pounds of seed drilled in rows 28 inches apart gave the highest yield of seed and the most economical yield of forage. It was also found that 2 bushels of seed to the acre gave the largest yield of forage, but it was not enough greater to pay for the extra quantity of seed used.

¹ Williams, C. G., and Park, J. B. Soy beans: Their culture and use. Ohio Agr. Exp. Sta. Bul. 312, p. 581-600, 4 fig. 1917.

METHOD OF SEEDING.

Under nearly all conditions the soy bean should be grown in rows and given sufficient cultivation to keep down the weeds. The yield of seed is nearly always greater when grown in cultivated rows. If the land is quite free from weeds and the crop is to be used for hay or soiling, however, drilling or broadcasting will furnish a forage of finer quality. The main objections to solid drilling or broadcasting are the larger quantities of seed required and the greater growth of weeds in cold, wet seasons. Broadcasting and covering the seed with a harrow are seldom advisable. In eastern North Carolina the soy bean is planted in rows 4 feet apart and ridged to facilitate drainage. For the best results the plants should be 2 to 4 inches apart.

The ordinary grain drill furnishes, perhaps, the most convenient means either for seeding in rows or broadcast. The width of the rows may be adjusted by covering the feed cups not in use. To prevent splitting the seed, the oats feed should be used. Corn planters can be used satisfactorily, as most of the modern planters have special plates for planting beans.

CULTIVATION.

Under favorable conditions the soy bean germinates in a few days, and cultivation should be begun as soon as the seedling plants appear (fig. 7). One deep cultivation may be given, but afterwards the cultivations should be shallow. The soy bean readily responds to good cultivation and requires about the same number of cultivations as corn. Level cultivation is preferable, as the harvesting can be more easily accomplished.

The harrow or weeder can be used advantageously on soy beans drilled solid which have been up a few days, as this is the only cultivation that can be given them.

VARIETIES.

The variety to be selected is a matter of prime importance and should be one adapted to local conditions and to the purpose for which the crop is grown. It is important, in view of the possibilities of this crop and its greater agricultural development in the United States, to utilize the very best varieties. As the number of soy-bean varieties is very large, and as new sorts are easily secured through selection and introduction, the most desirable characters, both for forage and seed production, need to be considered. Although yield is the most important single consideration, other factors are maturity, habit, coarseness, color of seed, ability to hold leaves, and ease of shattering. In view of the increasing interest in the soy bean for the production of oil, the percentage of oil is second to yield for seed production alone where the crop is likely to become of importance as an oil seed. At the present time about 20 varieties (fig. 6) of soy

beans are handled by growers and seedsmen in this country. During the past 10 years more than 800 lots of seed for testing, with a view to their introduction into this country, have been received by the United States Department of Agriculture from China, Manchuria, Japan, and India. Among these are several that have now become established on the market. Some of the recent introductions have proved so valuable in field trials that they are deemed important acquisitions, and seed will be distributed widely to further their culture.



FIG. 7.—Cultivating soy beans. Cultivation should begin as soon as the seedling plants appear.

Unfortunately, considerable confusion in the names of varieties has been caused by growers and seedsmen, the same variety being frequently known under several different names. With the introduction of more varieties, it is readily seen that greater confusion is likely to occur. It is desirable to limit the varieties in the seed trade to the very best sorts. Seedsmen and growers are urged to use the varietal names here adopted, and buyers should be careful to specify the variety desired.

The planting of seed imported from Asiatic countries is not to be advised. Such imported seed consists of a mixture of varieties, most of which are inferior to the best varieties grown in the United States. The United States Department of Agriculture has given considerable attention to the breeding and adaptation of pure strains, and it is believed that in the planting of imported seed an unnecessary risk is taken. The more important commercial varieties and recently im-

proved sorts, with their adaptations and characteristics, are here described.

Barchet.—A late variety, found especially desirable for hay and green manure on the rice lands in the Gulf States. It makes an abundant growth of fine forage. Plants slender, rather inclined to lodge on fertile soils, maturing in about 160 days; pubescence tawny; flowers purple; seeds brown, with a brown seed scar, small, about 645,000 to the bushel; oil, 11.8 per cent; protein, 45.9 per cent.

Biloxi.—This variety (fig. 8) is characterized by its dense bushiness, leafiness, and coarse, erect stems, growing from 4 to 6 feet high. As the Biloxi requires a very long season in which to make its full development, it is adapted only to the southern part of the cotton belt. It is especially suited

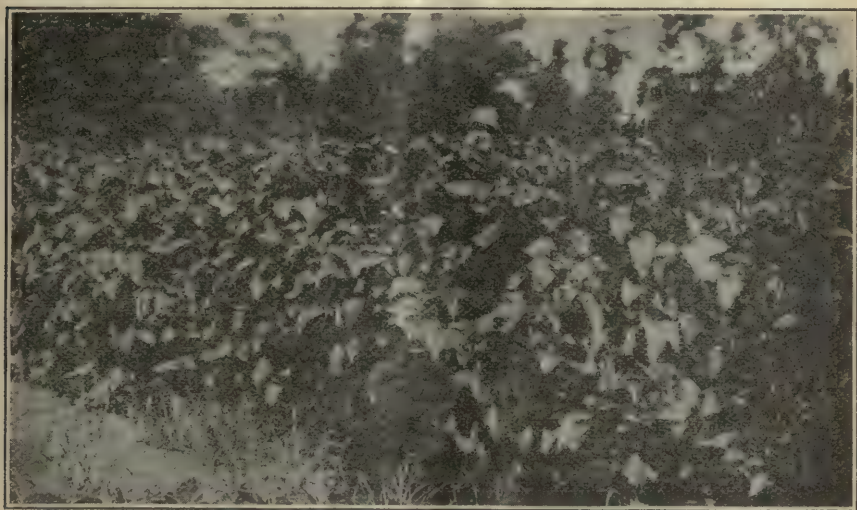


FIG. 8.—A field of the Biloxi variety of soy beans in Mississippi.

to the rice lands as a green manure and is also valuable for forage and ensilage. Pubescence tawny; flowers purple; seeds deep brown with a brown seed scar, much flattened, medium large, about 112,000 to the bushel; oil, 20.3 per cent; protein, 46.3 per cent.

Black Eyebrow.—A variety (fig. 9) obtained from Manchuria and found especially adapted to northern conditions both for grain and hay. Plants stout, erect, maturing in about 110 days; pubescence tawny; flowers both purple and white; seeds black, with brown saddle and black seed scar, medium sized, about 148,000 to the bushel; oil, 17.8 per cent; protein, 40.8 per cent.

Chiquita.—The Chiquita has given better results under dry conditions in the semiarid regions than any other variety. It produces not only an abundance of forage but also a heavy yield of seed. This variety is especially suitable for forage or pasture. Plants under favorable conditions semierect with twining terminals, maturing in about 135 days; pubescence tawny; flowers both purple and white; seeds straw yellow, with a brown seed scar, medium small, about 275,000 to the bushel; oil, 17.6 per cent; protein, 46.9 per cent.

Early Brown.—With the exception of the color of the seed, this variety can not be distinguished from Ito San.

Elton.—An early-maturing variety obtained from Siberia and found especially suitable as a grain producer for northern conditions. Plants stout, erect,

maturing in about 110 days; pubescence tawny; flowers purple; seeds straw yellow, with a pale seed scar, medium sized, about 130,000 to the bushel; oil, 17.4 per cent; protein, 40.3 per cent.

Guelph.—The Guelph is also known as Medium Green, Early Green, Medium Early Green, and Large Medium Green. It is esteemed for its forage and as a silage crop in the Northern States. Although a good producer of grain, it is not desirable for this purpose, since the pods shatter badly before all the seeds are mature. Plants stout, erect, maturing in about 115 days; pubescence tawny; flowers purple; seeds green, with a brown seed scar, medium sized, about 149,000 to the bushel; oil, 19.5 per cent; protein, 36.8 per cent.

Haberlandt.—The Haberlandt is a heavy yielder of seed and is also an excellent pasture variety. Plants stout, erect, maturing in about 125 days;



FIG. 9.—A field of the Black Eyebrow variety of soy beans in South Dakota.

pubescence tawny; flowers both purple and white; seeds straw yellow, with a deep-brown seed scar, medium sized, about 144,000 to the bushel; oil, 18.3 per cent; protein, 38.5 per cent.

Hahto.—This variety recently introduced from Japan is a large producer of seed and forage, and the seeds when from three-fourths to full grown make an excellent green vegetable, similar to the Lima or butter bean. Plants stout, erect, maturing in about 135 days; pubescence tawny; flowers purple; seeds olive yellow, with a black seed scar, much flattened, very large, about 75,000 to the bushel; oil, 14.8 per cent; protein, 40.6 per cent.

Hollybrook.—This variety is about two weeks earlier than the Mammoth and therefore can be grown farther north for grain. Plants stout, erect, maturing in about 135 days; pubescence gray; flowers white; seeds straw yellow, with a light-brown seed scar, medium sized, about 176,000 to the bushel, very similar to that of Mammoth, but somewhat smaller; oil, 16.8 per cent; protein, 40 per cent.

Ito San.—This variety is one of the earliest commercial sorts and has been known under the names of Japan Pea, Yellow, Medium Yellow, Dwarf Yellow, Early Yellow, Early White, and Coffee Berry. Although not a heavy yielder of seed or forage, the Ito San is a very desirable variety to grow in a

short season and is especially suited to northern conditions. Plants stout, erect, maturing in about 110 days; pubescence tawny; flowers purple; seeds straw yellow, with a pale seed scar, medium sized, about 172,000 to the bushel; oil, 16.6 per cent; protein, 40.3 per cent. The seed of this variety can always be identified by a little brown speck at one end of the seed scar.

Lexington.—This variety has been found especially suited to Kentucky for grain and forage. Plants stout, erect, maturing in about 125 days; pubescence gray; flowers both purple and white; seeds olive yellow, with a pale to light-brown seed scar, much flattened, medium small, about 215,000 to the bushel; oil, 19.1 per cent; protein, 34.5 per cent.

Mammoth.—The Mammoth (fig. 10) is the standard commercial late variety, more extensively grown at the present time than any other. It yields well both in grain and forage, but for grain it can not be expected to mature north



FIG. 10.—Plats of the Mammoth and Virginia varieties of soy beans at Arlington Farm, Va.

of Virginia and Tennessee. As forage, however, it can be utilized much farther north. Plants erect, coarse, maturing in about 145 days; pubescence gray; flowers white; seeds straw yellow, with a light-brown seed scar, medium large, about 129,000 to the bushel; oil, 18.6 per cent; protein, 37.6 per cent.

Manchu.—A variety, obtained from northern Manchuria, that has given excellent results in the Northern States both for grain and forage. Plants stout, erect, maturing in about 110 days; pubescence tawny; flowers purple; seeds straw yellow, with a slate-black seed scar, medium sized, about 141,000 to the bushel; oil, 19.18 per cent; protein, 37.19 per cent.

Medium Yellow.—A well-known variety that has been grown under the names Early Yellow, Mongol, Banner, and Roosevelt, and also erroneously as Hollybrook and Ito San. This variety gives an excellent yield of seed and is also suitable for forage. Plants stout, erect, maturing in about 115 days; pubescence tawny; flowers purple, seeds straw yellow, with a seed scar ranging from pale to light brown, medium small, about 262,000 to the bushel; oil, 19.3 per cent; protein, 34.1 per cent.

Mikado.—This variety, especially suited to the Central States, produces a good yield of seed and forage. It is about one week later than Medium Yellow, but otherwise appears to be identical with that variety.

Peking.—The Peking (fig. 11) is an excellent grain producer and with its rather fine stems and abundant foliage makes one of the best forage sorts. In variety tests the Peking, Sable, and Royal varieties appear to be identical, and it is quite evident that the latter two are selections from the Peking. Plants slender, erect, maturing in about 120 days; pubescence tawny (a small percentage of the plants have gray pubescence and twining terminals); flowers both purple and white; seeds black with a black seed scar, much flattened, medium small, about 384,000 to the bushel; oil, 15.9 per cent; protein, 39 per cent.

Shanghai.—This variety has been grown in North Carolina under the name of Tarheel Black. It gives a very good yield of seed and forage, but is inferior to many of the other sorts. Plants stout, erect, maturing in about 140



FIG. 11.—A field of the Peking variety of soy beans grown in 24-inch rows.

days; pubescence tawny; flowers white; seeds black, with a black seed scar, slightly flattened, medium sized, about 164,000 to the bushel; oil, 18.6 per cent; protein, 35.2 per cent.

Tokyo.—A variety giving rather a coarse growth, but an excellent producer of grain. It is especially suitable as a grain variety for North Carolina, Tennessee, and southward, being adapted to about the same area as the Mammoth. The plants are stout and erect, maturing in about 145 days; pubescence gray; flowers both purple and white; seeds olive yellow, with a pale seed scar, medium sized, about 135,000 to the bushel; oil, 18.4 per cent; protein, 35 per cent.

Virginia.—The Virginia (fig. 10) on account of its abundant growth and large yield of seed makes an excellent forage. It is recommended as a suitable variety for hay or ensilage and as such can be grown throughout the greater part of the corn belt. Plants slender, erect, with vining terminals, maturing in about 125 days; pubescence tawny; flowers purple; seeds brown, with a brown seed scar, much flattened, medium small, about 250,000 to the bushel; oil, 17.8 per cent; protein, 40.2 per cent.

Wilson-Five.—This variety is a pure field selection from the Wilson and produces an abundance of fine forage and a good yield of seed. Plants slender,

erect, maturing in about 120 days; pubescence gray; flowers purple; seeds black, with black seed scar, much flattened, medium small, about 328,000 to the bushel; oil, 18.4 per cent; protein, 37.8 per cent.

Yokotenn.—A variety found especially suitable as a grain for Tennessee conditions. Plants stout, erect, maturing in about 125 days; pubescence gray; flowers both purple and white; seeds straw yellow, with a pale seed scar, very large, about 70,000 to the bushel; oil, 19.2 per cent; protein, 36 per cent.

SOY BEANS IN ROTATIONS.

The soy bean may be combined advantageously in many systems of crop rotations. It is especially adapted to short rotations, taking either an entire season or a part of a season following some grain

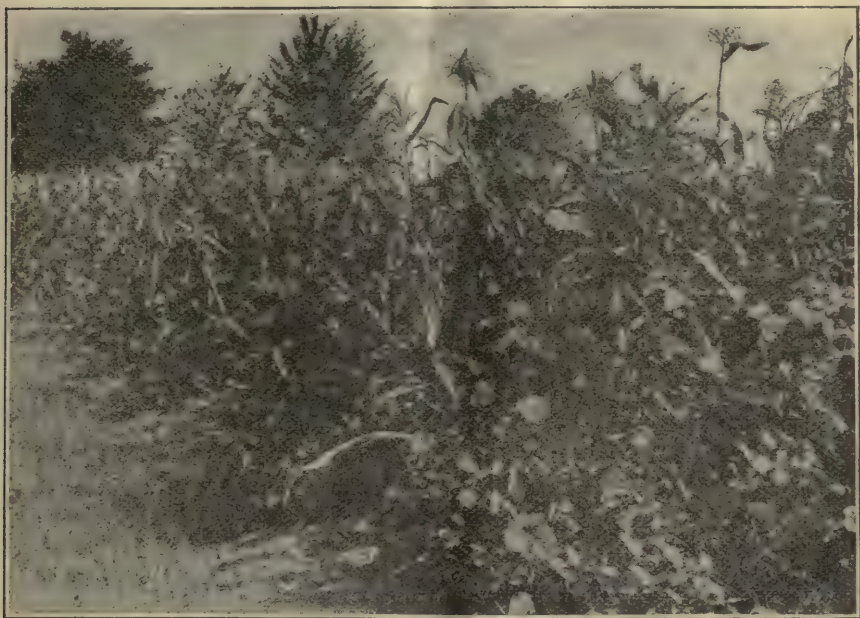


FIG. 12.—A field of soy beans and corn grown for ensilage.

crop. The cash value of the seed is sufficient to encourage growing the beans as one of the main crops. When the whole season is thus devoted to soy beans, they may take any place in a rotation system where corn can be used. In the Southern States the crop is adapted to practically the same place in rotations as cowpeas.

The small grains may follow soy beans, and the soil requires but little preparation after a crop of soy beans. In North Carolina and Tennessee a soy-bean crop is often grown between two wheat crops or between two oat crops. A rotation of corn, soy beans, wheat, and clover is practiced quite generally in many sections north of the Ohio River. In some sections the soy bean is substituted for oats in such 4-year rotations as corn, oats, wheat, and clover or potatoes, oats, wheat, and clover. The soy bean can also be used as a catch crop

where new seedings or grass and clover have failed and on wheat or oat stubble fields where clover or grass has not been sown or has not succeeded. As a crop after early potatoes or cannery peas and as an orchard cover crop, the soy bean is highly recommended, as it will produce a large quantity of fall pasturage or material for plowing under on soils in need of organic matter.

SOY BEANS IN MIXTURES.

The soy bean may be satisfactorily grown in combination with other farm crops. Although the chief advantage, perhaps, is a better balanced ration, the results of experiments indicate a larger yield of forage, as well as a greater variety.

SOY BEANS AND COWPEAS.

Soy beans and cowpeas make a very satisfactory mixture for hay or even for pasture, and the yield is nearly always greater than that of either crop alone. In this mixture tall strong-growing varieties of soy beans are desirable, as they tend to support the vining cowpeas. Varieties of these crops having about the same maturity should be selected.

In sowing a mixture of soy beans and cowpeas it is essential to have more soy-bean plants than cowpeas, so that the vining growth of the cowpeas may be supported properly. One bushel of soy beans and one-half bushel of cowpeas give excellent results if drilled broadcast, but if planted in 3-foot rows about one-half of this quantity of each is sufficient. The planting, whether in cultivated rows or broadcast, can be done best with an ordinary grain drill.

The time of cutting hay will depend on the relative stage of growth of the two crops. As nearly as possible, both plants should be at that stage of growth giving the best quality of hay. This time is when the soy-bean seed is about full grown and the first pods of the cowpeas are ripe. The harvesting and curing of a mixture of cowpeas and soy-bean hay is more easily accomplished than cowpeas alone, but is slightly more difficult than in the case of soy beans alone.

SOY BEANS AND CORN.

Soy beans are more generally grown with corn than with any other crop (fig. 12). Various methods of growing the two crops together are practiced in different sections of the country. The beans may be planted in the same hills with the corn, in alternate hills with corn in the same row, in alternate rows of each, or there may be two rows of each. The soy bean is rarely broadcasted in mixture with corn. In some sections the broadcasting of soy beans in corn at the last cultivation for hog pasture or soil improvement is quite generally practiced. When soy beans are grown with corn by these methods, the crop may be used for pasture or harvested for ensilage.

SOY BEANS AND SORGHUMS.

Soy beans grown in combination with sorghums make an excellent hay or ensilage crop. The tall-growing vining varieties of soy beans, like the Virginia and Wilson-Five, and either the Amber or Orange varieties of sorghum are preferable. This mixture is, perhaps, most satisfactory in cultivated rows, as the sorghum is apt to choke out the soy beans when broadcasted unless the sorghum is planted thinly. When sown in rows, about 15 pounds of sorghum and 45 pounds of soy beans will be sufficient.

SOY BEANS AND SUDAN GRASS.

Sudan grass is an excellent crop for growing in combination with soy beans (fig. 13). Not only a better yield, but a better balanced forage is obtained, as the Sudan grass is low and the soy bean high in protein. The best results are to be obtained by broadcasting, planting about 50 pounds of soy beans and 10 pounds of Sudan grass to the acre. This mixture is cut for hay about the time the soy-bean seeds are nearly full grown. The hay is easily harvested and cured.

SOY BEANS FOR SEED.

The soy bean is a very profitable crop when grown for seed, and the seed-growing industry is being developed in many cotton-growing sections and in the southern part of the corn belt. The character of growth, its uniform maturing habit, and its large yield of grain recommend the soy bean for seed production. The many disadvantages which attend the harvesting of cowpeas are not common to the soy bean.¹ The increased demand for seed for planting purposes and the utilization of the dried beans as food and for the production of oil and meal have brought about greatly increased prices. The seed of the best varieties of soy beans is selling for \$2.50 to \$4 per bushel of 60 pounds. As the merits of the crop are better appreciated, the demand is not likely to diminish. Utilizing soy-bean seed as feed is distinctly profitable. In addition to the value of the seed, the benefit to the land on which the beans have been grown and the use of the thrashed vines as a source of feed must be taken into consideration.

YIELDS OF SEED.

The average yields of soy-bean seed to the acre in various sections of the United States range from about 15 bushels in the Northern States to about 25 bushels in the northern part of the cotton belt. The average yield in eastern North Carolina, the largest seed-producing section in the country, is about 25 bushels, although many fields produce 35 bushels or more to the acre. Maximum yields of 50 bushels to the acre have been reported from North Carolina and Tennessee. The seed yields of the more important varieties now handled by growers and seedsmen are shown in Table II. These yields, as re-

¹ Morse, W. J. Harvesting soy-bean seed. U. S. Dept. Agr., Farmers' Bul. 886, 8 p., 7 fig. 1917.

ported by investigators at the various agricultural experiment stations, differ greatly with the same variety. This, in most cases, may be attributed to the adaptation of the variety to certain localities for seed production. In general, the figures show the average yields for a number of years and indicate the best seed-producing sorts.

TABLE II.—Average yields of seed to the acre of the best varieties of soy beans at different agricultural experiment stations.

Variety	Arlington Farm, Va.	Delaware.	Georgia.	Illinois.	Indiana.	Kansas.	Kentucky.	Maryland.	Mississippi.	Ohio.	Tennessee.	Virginia.	Wisconsin.
Mammoth.....	21.2	-----	14.9	-----	15.5	-----	18.0	10.1	36.6	-----	23.9	-----	-----
Hollybrook.....	18.1	29.2	9.7	-----	-----	-----	16.2	-----	14.6	-----	22.9	-----	-----
Guelph.....	18.2	15.2	-----	16.9	24.7	-----	-----	-----	14.6	23.9	16.5	16.6	21.3
Ito Sun.....	17.6	21.9	10.1	14.3	21.3	12.4	8.0	10.5	30.0	21.2	20.2	18.4	15.6
Haberlandt.....	25.8	23.3	13.9	21.7	-----	3.8	14.0	17.5	13.3	-----	25.7	18.3	-----
Medium Yellow.....	22.4	26.9	-----	13.3	23.0	19.7	-----	15.8	-----	22.2	25.9	-----	16.3
Wilson.....	25.5	32.2	14.2	18.4	20.1	-----	10.2	16.0	-----	-----	-----	-----	-----
Peking.....	30.5	32.7	14.1	11.0	18.6	-----	-----	16.7	23.3	-----	-----	15.0	-----
Ebony.....	16.4	25.2	-----	17.8	21.8	-----	10.0	19.8	-----	23.9	25.0	-----	-----
Virginia.....	26.6	27.1	21.8	-----	-----	-----	-----	20.1	-----	-----	-----	-----	-----
Early Brown.....	22.0	-----	-----	-----	21.7	17.7	-----	-----	-----	-----	18.1	-----	20.3

FEEDING VALUE.

The feeding value of soy-bean seed, which contains from 30 to 46 per cent protein, is very high and compares favorably with other concentrated feeds. The growing of soy-bean seed will enable the farmer to produce at a moderate cost at least part of the high-protein concentrates necessary for stock feeding and milk production. When fed to sheep and hogs, the beans can be fed whole, but in general it is preferable to crack or grind them. Practical experience has shown that it is necessary to mix the beans with corn or peas first and then grind together into meal. Owing to the high content of protein, soy-bean seed should always be fed in mixture with a less concentrated feed. The amount of digestible nutrients in soy-bean seed, as shown in Table III, would indicate that it compares very favorably with those of other concentrated feeds.

TABLE III.—Average digestible nutrients in soy-bean seed and other concentrates.¹

Feeding stuff.	Digestible nutrients (per cent).			
	Total.	Protein.	Carbo-hydrates.	Fat.
Soy-bean seed.....	85.9	30.7	22.8	14.4
Cottonseed meal (choice).....	78.2	37.0	21.8	8.6
Linseed meal (new process).....	75.9	31.7	37.9	2.8
Wheat middlings.....	69.3	13.4	46.2	4.3
Wheat bran.....	60.9	12.5	41.6	3.0

¹ Henry, W. A., and Morrison, F. B. Feeds and Feeding, ed. 17, 691 p. Madison, 1917.

Soy-bean seed ground into meal has been found a most excellent feed for dairy cows. The Massachusetts Agricultural Experiment Station¹ compared soy-bean meal and cottonseed meal, using the same

¹ Brooks, W. P. Relative value of cottonseed meal and soja-bean meal as food for milch cows. In Mass. Hatch Agr. Exp. Sta., 6th Ann Rpt., 1903, p. 13-14. 1904.

ration otherwise. The quantity of milk produced from the soy-bean ration was slightly larger. The butter from the cows fed cottonseed meal was of firmer texture, but not nearly as good otherwise as the butter from the cows fed soy-bean meal. These results would indicate, that ground soy beans are superior to cottonseed meal for both milk and butter production. At the Tennessee station,¹ in a similar comparison of the same two feeds, the yields both of milk and butter fat were about 5 per cent greater for the soy-bean meal. It was found at the Kansas station² that when soy beans formed one-half of the concentrates of the ration soft butter was produced.

As a supplement to corn meal for growing and fattening pigs, the Wisconsin station³ found that ground soy beans proved about 10 per cent superior to wheat middlings, figuring the cost of the feeds as the same. The Indiana station⁴ compared rations of two parts of corn meal and one part of soy-bean meal with corn meal and wheat middlings in equal proportions and with five parts of corn meal and one part of tankage for pork production. The soy-bean ration produced the largest daily gains, and this with the smallest quantity of feed consumed for each pound of gain. The Kansas station⁵ has tested the value of soy-bean meal in combination with corn meal and with kafir meal in comparison with the two latter feeds alone in feeding hogs. The feeds were mixed in the proportion of four-fifths corn or kafir and one-fifth soy beans. Larger gains, varying from 13 to 37 per cent, were made in every case on the mixed rations than on corn or kafir alone. The Missouri station⁶ in a comparative feeding trial of soy-bean meal with linseed meal and tankage showed that the three feeds were equally effective in promoting the growth of young hogs.

In feeding trials with sheep at the Wisconsin station⁷ soy beans produced larger gains for a given amount of feed and a heavier clip

¹ Price, J. N. Home-grown rations in economical production of milk and butter. *Tenn. Agr. Exp. Sta. Bul.* 80, p. 31-50. 1908.

² Otis, D. H. Experiments with dairy cows. *Kans. Agr. Exp. Sta. Bul.* 125, 141 p., 39 fig. 1904.

³ Humphrey, G. C., and Fuller, J. G. Soy beans versus wheat middlings as a supplement to corn meal for growing and fattening pigs. *In Wis. Agr. Exp. Sta., 21st Ann. Rept.* [1903]/04, p. 32-40, 6 fig. 1904; *22d Ann. Rept.*, [1904]/05, p. 21-30, 3 fig. 1905; *23d Ann. Rpt.* [1905]/06, p. 33-46, 3 fig. 1906.

⁴ Skinner, J. H. Soy beans, middlings, and tankage as supplemental feeds in pork production. *Ind. Agr. Exp. Sta. Bul.* 108, 32 p., 4 fig. 1905.

⁵ Cottrell, H. M., Otis, D. H., and Haney, J. G. A new drought-resisting crop—soy beans. *Kans. Agr. Exp. Sta. Bul.* 92, 28 p., 3 fig. 1900.

Erf, O., and Kinzer, R. J. Swine feeding test with sorghum-seed meal, kafir-corn meal, soy-bean meal, and corn meal. *Kans. Agr. Exp. Sta. Press Bul.* 141, 2 p. 1905.

⁶ Forbes, E. B. Specific effects of rations on the development of swine. *Mo. Agr. Exp. Sta. Bul.* 81, 69 p. 1909.

⁷ Richards, W. B., and Kleinheinz, Frank. The value of soy beans as a part of a grain ration for lambs. *In Wis. Agr. Exp. Sta., 21st Ann. Rpt.* [1903]/04, p. 51-55. 1904.

Humphrey, G. C., and Kleinheinz, Frank. The value of soy beans in grain rations for lambs. *In Wis. Agr. Exp. Sta., 22d Ann. Rpt.* [1904]/05, p. 65-68. 1905.

of wool. In one experiment two lots of 10 lambs each were fed the same roughage. One lot received shelled corn and whole soy beans in equal proportions, while the other received the same quantities of shelled corn and whole oats. The average gain of each lamb during a period of 12 weeks was 16.2 pounds when soy beans constituted a part of the ration and but 13.7 pounds when oats were used. A pound of gain was produced on 6.11 pounds of grain and 7.11 pounds of roughage in the soy-bean ration, while 7.28 pounds of grain and 8.62 pounds of roughage were required in the oats ration. In another experiment the same rations were fed for 12 weeks to two lots of



FIG. 13.—A field of soy beans and Sudan grass grown in mixture for hay.

8.62 pounds of roughage were required in the oats ration. In another experiment two lots of 10 lambs each were fed the same roughage. One lot received shelled corn and whole soy beans in equal proportions, while the other received the same quantities of shelled corn and whole oats. The average gain of each lamb during a period of 12 weeks was 16.2 pounds when soy beans constituted a part of the ration and but 13.7 pounds when oats were used. A pound of gain was produced on 6.11 pounds of grain and 7.11 pounds of roughage in the soy-bean ration, while 7.28 pounds of grain and 8.62 pounds of roughage were required in the oats ration. The second lot also consumed more feed per pound of gain.

FOR HUMAN FOOD.

In Asiatic countries, especially China and Japan, the soy bean and the various food products made from it are so largely consumed that it is second only to rice in importance as a food crop. Until 1916 the soy bean had been used but little in the United States for food and only as a special diet for persons requiring foods of a low starch content. Much interest has been shown during the last two years in the possibilities of the soy bean for food. The United States Department of Agriculture and many schools of cookery and domestic

science have conducted successful experiments in utilizing the dried beans in the manner of the navy bean and the green beans (fig. 14) when three-fourths to full grown as a green-vegetable bean. The variety and palatability of the forms in which the bean can be served make it a very desirable article of food, and undoubtedly it will grow in favor as it becomes better known. Soy-bean meal or flour may be used as a constituent of bread and muffins and in pastry.

FOR OIL AND MEAL.

Soy beans, in addition to their forage and food value, contain a valuable oil which is utilized to a very considerable extent in Europe

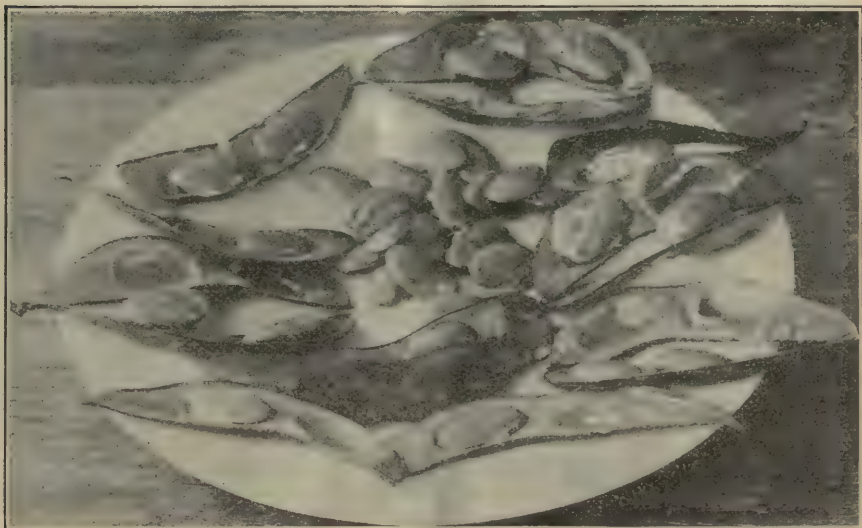


FIG. 14.—Seeds and pods of the Hahto variety of soy beans, the seeds being especially valuable as a green vegetable.

and America for culinary purposes, as a paint oil, in soap manufacture, and in many other industries.¹ The soy-bean cake remaining after the oil is expressed is ground into meal and makes a highly nitrogenous foodstuff which can be used for human food and as stock feed. Practical experience, supplemented by careful experiments, indicates the value of the meal as a feed for all kinds of live stock.

VIABILITY OF SOY-BEAN SEED.

The seed of the soy bean loses its viability rather rapidly, and it is not safe to plant seed 2 years old without a germination test. The seed spoils easily if not properly handled, and special care should be exercised in curing and storing it. Under favorable storage conditions well-cured seed will retain its viability four or five years, but this has been found to vary according to variety, as shown in Table IV.

¹ Piper, C. V., and Morse, W. J. The soy bean, with special reference to its utilization for oil, cake, and other products. U. S. Dept. Agr. Bul. 439, 20 p., 3 fig. 1916.

TABLE IV.—*Percentage of viability of the seed of different varieties of soy beans stored for periods of 1, 2, and 4 years.*

Variety.	Seed color.	1 year.	2 years.	4 years.
Shanghai.....	Black.....	99.0	93.0	43.5
Chernie.....	do.....	94.0	76.5	46.5
Jet.....	do.....	92.5	60.0	19.5
Ebony.....	do.....	94.0	71.5	4.0
Guelph.....	Green.....	97.5	86.5	1.5
Ito San.....	Straw yellow.....	100.0	83.0	2.5
Haberlandt.....	do.....	76.0	2.5	0
Mammoth.....	do.....	77.0	32.5	0.5

COST OF PRODUCTION.

The cost of production of soy-bean seed in general will be very little different from that for corn when the crop is planted in rows and cultivated. Usually soy beans are given one or two cultivations less than corn, but if the rows are spaced closer than those of corn the cost will be practically the same.

Data collected from leading growers of the soy bean in large seed-producing sections show the cost of production per acre to range from \$7 to \$17, with the average about \$10.50. In those sections where special bean harvesters are used for gathering the crop in the field, the cost of harvesting is less than when the vines are thrashed. However, the straw obtained in the thrashing of the vines is a valuable feed and brings from \$7.50 to \$12.50 a ton.

SOY-BEAN STRAW.

The straw obtained from thrashing the soy bean for seed is a valuable feed for all kinds of stock. In many sections where this crop is grown extensively for seed it is baled at the time of thrashing and sold in the immediate locality to liverymen, dairymen, and stock feeders.

The Ohio Agricultural Experiment Station¹ conducted a series of experiments to compare corn stover and soy-bean straw for fattening lambs when fed with shelled corn and linseed-oil meal. It was found that soy-bean straw produced 6.6 per cent greater gain on a smaller amount of feed per 100 pounds of gain than did corn stover.

The Tennessee station² compared soy-bean straw and corn stover as roughage in the production of milk and butter. The ration containing soy-bean straw was found superior to that containing corn stover. This ration produced more pounds of milk and butter fat and produced them more cheaply than the corn-stover ration. In every case there was less loss in milk and butter fat during the feeding of soy-bean straw than during the feeding of corn stover. It was concluded from these tests that soy-bean straw is a valuable addition to the roughage in the feeding of dairy cows.

¹ Carmichael, B. E., and Hammond, J. W. Rations for fattening range lambs. Ohio Agr. Exp. Sta. Bul. 245, p. 685-722, 4 fig. 1912.

² Price, J. N. Home-grow rations in economical production of milk and butter. Tenn. Agr. Exp. Sta. Bul. 80, p. 31 50. 1908.

SOY BEANS FOR HAY.

The soy bean when cut at the right stage of growth and properly cured makes an excellent hay of high feeding value that is greatly relished by all farm animals. As compared with hay from other leguminous crops, soy-bean hay is equal or superior to any. The use of this hay as a source of protein, which can be produced on the



FIG. 15.—Soy-bean hay on frames. Under unfavorable weather conditions hay can be successfully cured in this way.

farm to balance feeds for growing stock or for milk, should reduce the quantity of high-priced concentrated feeds which it is necessary to purchase.

TIME OF CUTTING.

The soy bean may be cut for hay at any time from the setting of the seed until the leaves begin to turn yellow. The crop is best fitted for hay, however, when the seeds are well formed, for at this stage of growth the largest yield and the best quality of hay will be obtained. If the harvesting is done earlier, the percentage of protein will be higher, but the total yield will not be so large and the difficulty of curing much greater. If the cutting is delayed, the stems rapidly become hard and woody and decline in feeding value, and if left too long there is much loss in leaves. Table V shows the variation in the composition of hay of the Mammoth variety at different stages of development.

CURING SOY-BEAN HAY.

Soy-bean hay can be much more readily and easily cured than that of cowpeas. Under promising weather conditions the cutting may begin as soon as the dew is off the plants and continue for the rest of the day. After being left in the swath until thoroughly wilted

the hay should be raked into windrows before the leaves become dry and brittle and left for a day or two, depending on the weather. The hay can then be placed in small shocks or bunches. Most of the curing is done in the shock, and if well put up the hay will withstand considerable wet weather without damage. Four or five days of fair weather is ample time for making soy-bean hay ready to be stacked or housed. The bunches should be opened a few hours before hauling.

TABLE V.—*Composition of soy-bean hay at different stages of development.*¹

Stage of growth.	Constituents (per cent).					
	Moisture.	Protein.	Fat.	Nitrogen-free extract.	Fiber.	Ash.
Full bloom.....	5.11	19.22	1.45	38.56	26.50	9.16
Pods forming.....	5.35	12.72	1.06	42.50	30.82	7.55
Seed half developed.....	5.40	10.31	2.34	44.73	30.45	6.77
Seed fully developed.....	5.30	15.94	7.83	38.76	25.97	6.20

¹ Analyses made by the Bureau of Chemistry, U. S. Department of Agriculture.

Under unfavorable weather conditions curing frames can be used to good advantage. These frames are usually three or four sided pyramids made of boards or poles 3 to 6 feet long, fastened together at the top and held by crosspieces near the base (fig. 15). With these frames a hollow shock is formed, thus allowing the free circulation of air, which lessens the danger of spoiling and secures better curing. Although the hay, as a general rule, should be in a well-wilted condition when placed on the frame, well-cured hay has been obtained by placing the soy-bean plants on the frames as soon as cut.

Soy-bean hay should be thoroughly cured before it is stacked or housed. The hay may be placed in good-sized stacks or under cover. When stacked in the open it is essential that grass or some other material that sheds rain be placed over the stack. Poles or logs placed in the center of the stack so as to leave passages for air will greatly lessen the danger of spoiling.

FEEDING VALUE OF SOY-BEAN HAY.

The chief value of soy-bean hay lies in its high content of digestible protein. In feeding value it is superior to red clover or cowpeas and, as indicated by comparative feeding tests, is equal to alfalfa for milk and butter production. Soy-bean hay makes an excellent winter ration for young cattle, sheep, and horses when fed in mixture with roughage or other hay and has been used to good advantage for hogs. The feeding of soy-bean hay alone is not to be advised, because on account of its high feeding value digestive troubles may result. Table VI shows that the amount of digestible nutrients in soy-bean hay compares very favorably with the hay of other important crops. The relative value of feeds is, however, best shown by comparative feeding tests.

TABLE VI.—Average digestible nutrients in soy-bean hay compared with other important hay crops, air-dry basis.¹

Kind of hay.	Digestible nutrients, air dry (per cent).			
	Total.	Protein.	Carbo-hydrates.	Fat.
Soy bean.....	53.6	11.7	39.2	1.2
Cowpea.....	49.0	13.1	33.7	1.0
Alfalfa.....	51.6	10.6	39.0	.9
Red clover.....	50.9	7.6	39.3	1.8
Timothy.....	48.5	3.0	42.8	1.2

¹ Henry, W. A., and Morrison, F. B. Feeds and Feeding, ed. 17, 691 p. Madison, 1917.

The Tennessee Agricultural Experiment Station¹ conducted a feeding test with milch cows, comparing soy-bean and alfalfa hay in combination with corn ensilage and corn-and-cob meal. Each lot of cows consisted of four Jerseys, and the test lasted through three periods of 30 days each. At the conclusion of the test the results showed that the lot fed soy-bean hay produced 245 more pounds of milk and 20.5 more pounds of butter fat than the lot receiving alfalfa hay. In feeding tests with milch cows at the Ohio station² a ration of 8.7 pounds of soy-bean hay, 31.79 pounds of ensilage, 5.7 pounds of corn meal, and 1 pound of cottonseed meal gave as good results as a ration of 8.4 pounds of concentrates (equal parts by weight of wheat bran, cottonseed meal, and corn meal), 7 pounds of corn stover, and 32.8 pounds of ensilage. The feed cost of the butter fat, however, was 9.5 per cent lower in the soy-bean hay ration.

YIELDS OF SOY-BEAN HAY.

The soy bean will yield from 1 to 3 tons of hay to the acre, and occasionally 4 tons, depending upon the fertility of the soil and the season. Under favorable conditions soy beans should average at least 2 tons to the acre. Yields of hay of important varieties secured at various experiment stations are shown in Table VII.

TABLE VII.—Yields per acre of soy-bean hay obtained at different agricultural experiment stations.

Variety.	Arlington Farm, Va.	Connecticut.	Delaware.	Georgia.	Illinois.	Indiana.	Kansas.	Maryland.	Mississippi.	New Hampshire.	Ohio.	Tennessee.	Virginia.
Mammoth.....	1.8	---	---	1.9	2.1	1.6	---	---	2.2	2.1	1.9	2.8	2.9
Hollybrook.....	1.6	1.3	2.3	1.1	1.8	---	---	---	1.8	2.4	---	2.6	3.0
Guelph.....	1.8	1.6	2.2	---	1.8	2.7	---	---	1.5	2.6	2.7	2.3	1.6
Medium Yellow.....	2.2	1.2	2.3	---	2.1	---	2.8	4.5	2.6	1.9	---	2.3	2.3
Ito San.....	1.4	1.3	1.6	1.0	1.4	2.4	2.4	---	2.4	2.4	2.4	2.2	2.6
Ebony.....	1.4	---	1.9	---	1.6	2.4	1.2	4.3	---	1.9	2.4	---	---
Peking.....	2.1	1.6	2.4	1.4	---	2.2	2.6	3.6	1.7	2.1	2.2	---	---
Haberlandt.....	1.9	---	2.9	1.0	1.8	---	---	---	1.1	2.6	---	2.7	---
Wilson.....	2.3	1.7	2.6	1.2	1.7	---	---	3.0	---	2.3	---	---	---
Arlington.....	1.8	1.6	2.3	---	---	---	---	3.1	1.8	---	---	---	---

¹ Price, J. N. Home-grown rations in economical production of milk and butter. Tenn. Agr. Exp. Sta. Bul. 80, p. 31-50. 1908.² Caldwell, R. E. The value of soy-bean and alfalfa hay in milk production. Ohio Agr. Exp. Sta. Bul. 267, p. 125-145, 2 fig. 1913.

SOY BEANS FOR SOILING.

The soy bean has an important place among soiling crops. Having a high protein value, the crop may be fed to good advantage with less nitrogenous crops, such as corn, sorghum, Sudan grass, and millet. The great variation in the time of maturity of the different varieties of soy beans or the planting of the same variety at different dates will make it possible to have a succession of green forage throughout the greater part of the summer and fall. When the crop has become well established, it grows well during drought and often succeeds when other crops fail.

SOY BEANS FOR PASTURE.

The soy bean can be utilized to advantage as pasture for all kinds of stock, the most profitable method, perhaps, being to pasture with hogs, supplementing the corn ration. This is especially desirable when the harvesting is interfered with by bad weather, lack of labor, or other causes, and when the crop is grown for soil improvement. In this way the crop is profitable not only from the standpoint of feeding value, but also in the increase of soil fertility due to the manure and refuse vines. Hogs greatly relish the bean plant, especially the ripening pods and seed, and a considerable part of the growth of young hogs may be made with soy-bean pasture. Animals ready for fattening may be fitted for market much more rapidly if soy beans are used to supplement the corn ration. In pasturage experiments conducted at the Alabama Agricultural Experiment Station¹ soy beans, peanuts, chufas, and sorghum were compared as pasturage for hogs. It was found that when corn alone was fed, 100 pounds of pork cost \$7.63; when fed a two-thirds ration of corn and pastured on chufas in addition, 100 pounds of pork cost \$8.89; on sorghum, \$7.79; on peanuts, \$3.20; and on soy beans, \$2.74. The average gain of the pigs each day on the soy-bean pasture was 1.02 pounds, on the peanut pasture 1.01 pounds, on the chufa pasture 0.72 pound, and on the sorghum pasture 0.37 pound. The same station² reports three years' work in feeding 105 hogs to determine the value of soy-bean pasture as compared with other feeds, the most profitable quantity of corn as a supplement, and the effect of the soy-bean forage on the quality of the pork. It was found that when corn was used alone the average daily gain for each hog was 0.375 pound, at a cost of 7.61 cents. When soy-bean pasture was grazed with a one-fourth, one-half, and three-fourths ration of corn the average daily gains were raised to 1.102, 1.006, and 1.329 pounds, respectively, and

¹ Gray, D. T., Duggar, J. F., and Ridgeway, J. W. Feeds supplementary to corn for southern pork production. Ala. Agr. Exp. Sta. Bul. 143, p. 27-77. 1908.

² Gray, D. T., Ridgeway, J. W., and Eudaly, E. R. Corn, soy-bean pastures, tankage, cottonseed meal for fattening hogs. Ala. Agr. Exp. Sta. Bul. 154, p. 43-87, 9 fig. 1911.

the cost of pork reduced to 2.59, 3.36, and 3.17 cents, respectively. One acre of soy-bean pasture afforded grazing for 10 hogs for 32 days with a one-fourth ration of corn, 48 days with a one-half ration, and 62 days with a three-fourths ration of corn. The total value of pork produced on each acre of soy-bean pasture varied from \$25.84 to \$39.13. The Kentucky Agricultural Experiment Station,¹ in a series of experiments with soy-bean pasture for hogs, found that it was not profitable to hog down soy beans (grain) unless a supplementary feed is given. The results showed, however, that it was highly profitable to hog down soy beans if a supplementary feed, such as corn, is given. The lot of hogs receiving 2 per cent of its weight in corn meal daily produced 825 pounds of pork to the acre, at a cost of \$4.54 per hundred pounds of gain. An acre of soy beans hogged off with a supplementary feed of corn produced feed for 10 hogs for 21 days and for 20 hogs for an additional 21 days. An acre of soy beans with no corn fed the hogs produced feed for 10 hogs for 21 days and for 15 hogs for an additional 14 days.

Various methods of seeding are used when the soy bean is to be utilized for pasture purposes. In the Southern States, especially North Carolina, where a considerable acreage is used for hog pasture, from 1½ to 2 bushels of seed are sown broadcast at the last working of the corn. The hogs are turned in when the seed is fully mature. Corn and soy beans are sometimes grown together and pastured down, as is often done with corn, or the two crops may be planted in alternate rows. For young hogs the beans are often planted alone. Soy-bean pasture may be supplied for a period of several weeks by planting early, medium, and late varieties. Early-maturing varieties may be sown after small grains and make sufficient growth to supply considerable feed in the fall. Soy beans may be pastured at any time from the stage when the pods are one-half filled until the beans are mature. The usual practice is to turn the hogs into the beans when the seeds are about full grown, although in some sections this is not done until the seeds are mature.

When hogs have been pastured on soy beans alone there is a tendency for the lard to become soft. This may be overcome very materially by feeding the hogs on a grain ration after taking them from the pasture. The feeding of corn alone for four or five weeks has produced firm lard, while corn and cottonseed meal used in the proportion of 3 parts of corn to 1 part of cottonseed meal has given the best results.

SOY BEANS FOR ENSILAGE.

The use of soy beans alone for ensilage is not to be recommended, as shown by the results obtained by various experiment stations. The

¹ Good, E. S. Hogging down soy beans and cowpeas. Ky. Agr. Exp. Sta. Bul. 201, p. 139-149, 2 fig. 1916.

Wisconsin station¹ found that soy-bean ensilage alone was not readily eaten by stock, had a rank unpleasant odor, and produced a bad effect in the quality of the milk, butter, and cheese. Somewhat similar results were obtained at the Michigan station.

The soy bean, however, forms a valuable supplement to corn for ensilage, and the growing of the crop for this purpose has increased extensively throughout the Northern States and in some of the Southern States. The high content of protein and rather low content of carbohydrates in soy beans tend to produce strong-smelling objectionable ensilage, while their dilution with corn—about two or three parts corn and one part soy beans—reduces the danger of strong odors, makes a well-balanced ensilage that keeps well, is readily eaten by stock, and produces no bad effects in the quality of milk and its products. Corn in itself makes rather a wide ration, and should be supplemented with feeds richer in protein to balance the ration. The Maine Agricultural Experiment Station,² in an experiment with six cows, comparing soy-bean and corn ensilage with corn ensilage alone, found that the cows on soy-bean and corn ensilage with 1 pound less grain did practically as well as on corn ensilage. In all feeding tests with soy-bean and corn ensilage the animals showed good gains in flesh and milk production.

Various methods are employed in growing and working the two crops in the silo. The easiest, least expensive, and perhaps the commonest way is to mix two-thirds corn and one-third soy-bean seed and plant it the same as corn. With this method the planting is all done at one operation and the crop cared for in accordance with the common practice for corn. Another method of mixing the seed is to add to the regular seeding of ensilage corn 8 pounds of soy-bean seed to the acre. The growing of the two crops together is advisable only where the soil and climatic conditions are suitable.

Under conditions where corn grows tall and leafy much larger yields of soy beans will be obtained by growing the crop in a separate field. Results secured by the Cornell Agricultural Experiment Station³ do not favor the two crops together, as the beans are likely to be crowded out in competition with the corn. It would also appear that the harvesting and maintaining of the desired proportions of beans and corn can be more certainly accomplished by growing the two crops separately. In filling the silo from separate fields of soy beans and corn, the ratio usually runs one load of beans to two loads of corn, though in some sections three loads of corn are used.

¹ Woll, F. W., and Humphrey, G. C. Soy-bean silage as a food for dairy cows. *In* Wis. Agr. Exp. Sta., 21st Ann. Rpt. [1903]/04, p. 67-74. 1904.

² Woods, C. D., and Bartlett, J. M. Soy beans in Maine. *In* Maine Agr. Exp. Sta. Bul. 106, p. 113-121. 1904.

³ Minns, E. R. Soy beans as a supplementary silage crop. N. Y. Cornell Agr. Exp. Sta. Bul. 310, p. 259-274, fig. 53-58. 1912.

Soy beans may be used for ensilage at any time from the appearance of the first bloom until the seeds are full grown. The best results, however, are obtained if the plants are cut when the seed is about half grown. The crop may be harvested with a side-delivery reaper or with a binder. The latter implement is, perhaps, most satisfactory, as the beans can be handled in bundles and without waste.

SOY BEANS FOR SOIL IMPROVEMENT.

The value of a crop of soy beans for soil improvement depends upon the amount of available plant food which it adds to the soil and the effect which the roots have upon the mechanical condition of the soil. Leguminous plants, through the aid of the root-tubercle organisms, are able to add to the available nitrogen of the soil and therefore are extensively used in restoring soils that are deficient in that element. The fertilizing value of a crop of soy beans compares favorably with that of other legumes commonly grown for green manure.

Some rather extensive experiments were carried on by the Michigan Agricultural Experiment Station¹ to compare soy beans and other legumes as green-manuring crops. Taking the approximate yields of the legumes as a basis and adding to the fertilizing constituents in the forage the amounts that would be found in the weight of roots going with that amount of forage, the total amounts of the fertilizing constituents are shown in Table VIII.

TABLE VIII.—*Fertilizing constituents in different legumes grown at the Michigan Agricultural Experiment Station.*

Legume.	Fertilizing constituents (pounds).			
	Hay.	Nitrogen.	Phosphoric acid.	Potash.
Soy beans.....	5,860	152.29	27.38	100.89
Cowpeas.....	3,575	61.90	15.45	77.20
Vetch.....	3,000	77.10	18.58	63.12
Clover (second crop).....	2,000	51.47	12.05	36.18
Clover (new seeding).....	2,170	49.06	11.61	63.55

The Kansas Agricultural Experiment Station² reports an increase of 14 bushels of corn to the acre where corn followed soy beans in alternate years as compared with corn grown continuously. At the Arkansas station³ soy beans used as green manure gave nearly as good results as cowpeas, as determined by subsequent crops of wheat, oats, cotton, and corn. Soy-bean vines produced a larger yield of cotton than cowpea vines, but the cowpea stubble gave a larger yield than

¹ Smith, C. D. Legumes other than alfalfa. Mich. Agr. Exp. Sta. Bul. 227, p. 167-184. 1905.

² Ten Eyck, A. M., and Call, L. E. Cowpeas. Kans. Agr. Exp. Sta. Bul. 160, p. 179-209, 10 fig. 1909.

³ Newman, C. L. Oat experiments. Ark. Agr. Exp. Sta. Bul. 66, 23 p. 1901.

the soy-bean stubble. With corn, cowpea stubble and soy-bean stubble gave about the same results, while the soy-bean vines gave better results than the cowpea vines. The results with oats were slightly in favor of cowpeas.

It is hardly practicable to grow soy beans for green manure alone, as it is too valuable a crop to plow under for soil improvement except under certain conditions. The soy beans may follow wheat or oats and make sufficient growth to add considerable organic matter to the soil for wheat or other fall-sown crop. Soy beans should not be allowed to mature before plowing them under. When the plant has reached the blossoming stage, most of the nitrogen has been gathered.

ENEMIES OF THE SOY BEAN.

As yet the soy bean is troubled by few serious enemies. In general, it may be said that no insect or fungous pest has assumed any great economic importance in connection with the culture of this crop.

Rabbits are most troublesome, as they are very fond of the soy-bean plant and have been known to destroy considerable areas. Where rabbits are abundant, soy-bean culture in small areas is practically impossible unless the field can be inclosed with rabbit-proof fencing. In some of the Northern States, woodchucks have caused considerable damage to small plantings of the soy bean.

Root-knot caused by a nematode often causes considerable injury to soy beans in many sections of the Southern States where this pest is prevalent. In sections where the pest has become well established in the soil, soy beans should not be planted. To plant them is a dangerous practice, not only because the bean crop will be reduced, but also because the pest can propagate freely and greatly damage any susceptible crop which follows the soy beans.

Cowpea wilt, due to a *Fusarium*, causes considerable damage to the soy bean. One variety, unnamed as yet, is highly resistant to this disease and has given quite good results on soils infested with wilt.

Caterpillars sometimes eat the soy-bean foliage, but the damage from such insects is seldom serious. The black blister beetle has been reported in a few cases to have done considerable damage to soy-bean fields, but in general this insect can not be considered a serious pest.

CLEARING LAND

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FARMERS' BULLETIN 974

UNITED STATES DEPARTMENT OF AGRICULTURE

OFFICE OF THE SECRETARY

Contribution from the Office of Farm Management

W. J. SPILLMAN, Chief

Washington, D. C.

August, 1918

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METHODS OF CLEARING land that have proved successful in the cut-over sections of the United States are presented briefly in this bulletin. Various methods of burning stumps and different types of mechanical stump pullers are described, the advantages of the use of dynamite are set forth, and approved methods of pasturing stump land to keep down sprouts are outlined.

On many farms at the present time there are small tracts of woodland that might be profitably cleared. When such operations can be undertaken in spare time and without interruption to regular farm work, farmers can profitably increase their tillable area.

CLEARING LAND.

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CUT-OVER LAND, or land from which the stand of merchantable timber has been removed, may be found in all of the timbered States, but most of our cut-over acreage is located in the Southern States, where there are over 100,000,000 acres; in the Lake States, where there are over 30,000,000 acres; and in the Northwestern States, where there are over 8,000,000 acres. On much of this cut-over land there is at the present time sufficient valuable second growth to warrant keeping it for permanent timber land. Also, much of the cut-over land lying idle has a greater relative value for timber than for crop production, and steps should be taken to establish a valuable forest growth; but there are in the aggregate great areas of good cut-over land in farms lying idle—not even growing timber—that is worth more for crop than for timber production. On thousands of farms throughout the cut-over sections the most vital problem in normal times is how to get this unproductive land cleared so that it will bring in an increase of revenue. On many farms in the East and Middle West there are tracts covered by woods and brush that are better adapted to crop production than to forest growth.

This publication does not attempt to decide the important question whether or not any particular tract of land will pay better in field crops than in forest. It simply presents as briefly as possible some of the methods of clearing cut-over lands that investigations by the Office of Farm Management have found to be successful.

Most cut-over land passes through three stages of development before it reaches its greatest value agriculturally. The waste and small growth is first disposed of. It then remains in stumps a few years until the smaller stumps are dead or decayed, during which time it is pastured or may even be cultivated. Finally all the stumps are removed.

DISPOSAL OF WASTE AND SMALL GROWTH.

If there is a great amount of worthless growth, it should be cut and piled before the valuable growth is removed.¹ In most cases, however, this is not necessary. The best time to cut is when the trees are in full leaf, since then the stumps are least likely to sprout and the leaves on the trees assist materially in burning brush. Probably most second growth, however, is cut in the winter or early spring because there is always more spare time then than at other seasons

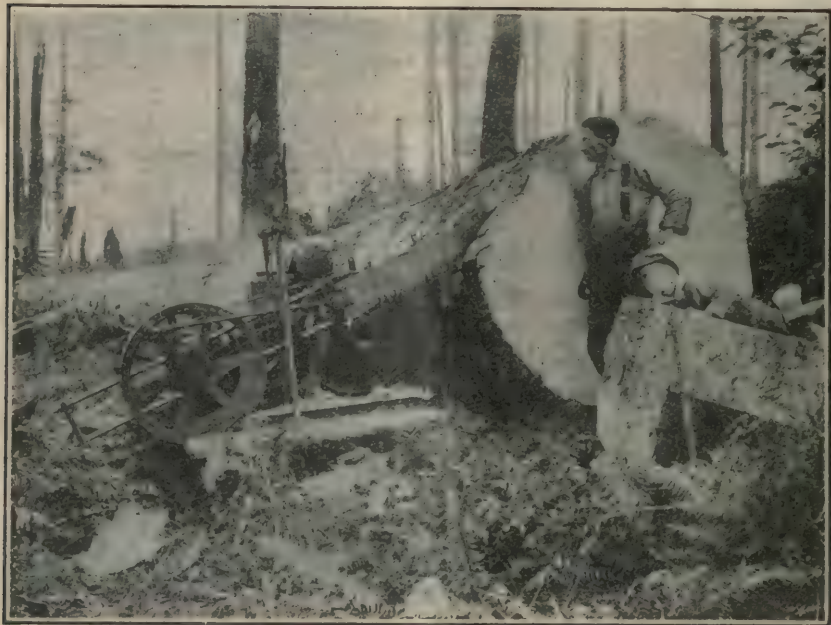


FIG. 1.—A small drag-saw outfit operated by one man. This is used to saw the big trees of the Pacific Northwest into firewood. It is mounted on skids and is pulled along for each new cut by means of a winch and cable.

of the year. In some cases it is advisable to leave part of the growth on a tract, because of its value as a windbreak, shade for stock, or a preventive of soil erosion.

Generally it is best to cut brush as close to the ground as possible and avoid leaving sharp points on the stubs that might injure work stock or cattle. If the wood is of no value and if it is not planned to cultivate the land before stumping, it may be best to cut off the trees rather high above the ground. If stumps are left 3 feet high there will be less sprouting than if cut close to the ground, and stumps left at that height may be more easily pulled.

¹ See "Measuring and Marketing Woodlot Products," Farmers' Bulletin 715, Division of Publications, U. S. Department of Agriculture, Washington, D. C.

Sometimes it is economical to deaden part of the large, worthless trees by girdling. (Fig. 2.) There will be the least sprouting if this is done when the trees are in full leaf.

In parts of Florida there is often a dense growth of palmetto. The palmetto roots are usually grubbed out by means of a mattock and piled and burned with the worthless timber.

The brush should be heaped into compact, conical piles. It is important to pile the brush close in order to get a good burn. If the brush is piled in windrows it is a good plan to run the windrows so



FIG. 2.—This land has been in cultivation six years. All the small stumps have decayed. These gum and oak trees were not worth removing. They probably will remain on the tract until they fall over. Note how deeply the trees have been girdled.

that neither side will be in the shade all day and as nearly parallel to the prevailing winds as it is possible to run them and still permit the sun to shine on both sides. This facilitates burning.

In most cases the worthless logs should be burned at the same time as the brush. On the Pacific coast, however, owing to the great amount of such material left on the ground, it will be practically impossible to burn all the logs when the slashings are disposed of. When it is the intention to burn the stumps in the ground it is advisable to leave enough logs for fuel.

In some places the brush is burned as soon as cut. Ordinarily it is well to wait until it is seasoned. The safest time, if not really the

best, to burn slash is after the summer or fall rains. A great deal of burning is done during dry times in summer, but many destructive fires are caused by carelessness in brush burning. In some States brush burning is prohibited, and some State laws hold a brush burner liable for damages if, through negligence, he allows fire to escape from his property.

Settlers clearing land in or near national forests should notify forest officials before proceeding to burn brush, and in all districts having a fire warden a permit from him should be obtained before



FIG. 3.—Logged-off land in western Washington. This land has been slashed and burned and is used for pasture.

any burning is attempted. In all cases ample precautions should be taken to prevent the spread of fire.

Growth on swamp land or any soil containing a large amount of organic matter should be burned when the ground is wet to prevent the destruction of valuable plant food. When soils do not contain a large amount of organic matter and it is the intention to seed in the ashes immediately after the burning, too much emphasis can not be placed upon the importance of getting a clean burn.

PASTURING STUMP LAND AND KEEPING DOWN SPROUT GROWTH.

Land is usually pastured several years after the small growth is disposed of before it is stumped (fig. 3). When land is kept in

pasture for several years before any stumps are removed, many of the small stumps will entirely decay and the fibrous roots of the larger ones will have become so weakened by decay that it is much easier to remove them.

In order that the pasturage may remain good and the stumps decay it is very important to keep sprout growth down. Second-growth hardwood stumps, especially those of comparatively young trees, sprout very prolifically. (Large stumps of any species of tree sprout much less than small ones.) The most successful method of keeping down sprout growth is by heavy pasturing with goats, sheep, or cattle, in the order given. When goats are kept on a tract for about two years they will destroy most of the sprouts and briers.

Some make a practice of pasturing the new land with goats for a few years. After the goats have killed most of the small growth, and grass has begun to come in, dairy cattle are substituted. If goats are used in subduing the sprouts, it is unnecessary to cut all of the small growth.

Any sprouts not killed by pasturing should be cut off or knocked off with the head of an ax. Whenever possible it is best to cut sprouts several times during the growing season, the object being to starve the roots. If this can be done only once during the growing season, it should be done in the late summer.

In most cases after the tract has been burned over it should be seeded lightly. Generally, however, one is not warranted in spending much over \$1 per acre for grass seed. On many tracts, particularly those of the Pacific Northwest region, grass seed is sown in the early fall following a burn and before the ashes have been settled by rains.¹ In the Lake States the usual procedure, if the burn is made in the summer, is to harrow or disk immediately after burning and then sow timothy. The following spring when the snow is 1 or 2 inches deep, or as the frost leaves the ground, clover seed is sown. Sometimes all the grass seed is sown in the spring.

In the longleaf pine belt the land is burned over each year to improve the pasturage. Wherever Bermuda grass will grow a pasture may be started by digging up the roots from an established field and transplanting them to the new land late in the winter.

On the Pacific coast many logged-off pastures may be considerably improved if the ferns that infest them are cut and burned about August each year.

If the weeds and sprouts in a pasture are kept under control, native grasses will gradually establish themselves even if no seeding has ever been done.

¹ More details regarding pasturing may be found in "Utilization of Logged-Off Land for Pasture in Western Washington and Western Oregon," Farmers' Bulletin 462, for sale by the Superintendent of Documents, Government Printing Office, Washington, D. C. Price 5 cents.

In some places there is such a large amount of worthless logs on the ground that some of them must be disposed of before the land can be pastured. Often it is advisable to stump the land partially while it is in pasture.

CULTIVATING STUMP LAND.

In the South, where usually the natural pastures are poor, it is the custom to cultivate the stump land instead of pasturing it. Another reason why stump land in the South is more generally cultivated than elsewhere is that most of the stumps there are tap-rooted and have few large lateral roots to interfere with tillage operations.

In some areas of the southern pine belt there is very little small growth to be disposed of. An easy method of getting this land into cultivation is to deaden the larger worthless trees, cut the small growth, grub out the small stumps, and burn. Later the deadened trees may be removed and the stumps taken out.

PULLING STANDING TREES.

Often it is advisable to clear the land completely at once. In that case it may prove to be most economical to remove entire trees without cutting. An important objection to this method is the great amount of work required to clean the earth from the roots of the green tree. In all except very sandy soils this is a hard task.

It is easier to pull a standing tree than it is to pull the green stump of the same tree, because a hitch can be made high on the trunk of the tree to give a powerful leverage on the roots. However, unless the trunk is rigid enough to stand the strain of pulling without bending, it is a waste of time to try to pull a tree in this manner. Ordinarily the hitch should be made about 4 or 5 feet above ground, though if one is pulling large trees with a hand stump puller the hitch can be made 15 or 20 feet above ground. It helps to place against the trunk of the tree a heavy block of wood to act as a fulcrum when the tree is pulled over.

If some of the roots are cut with an ax as the tree gradually bends over it may be pulled out with considerably less power. Trees may be pulled by any of the methods of stump pulling described later.

PLOWING SMALL GROWTH UNDER.

Small growth up to about 3 inches in diameter can be plowed under by the use of a very heavy special plow, drawn by a powerful traction engine. These plows turn a furrow 12 to 18 inches deep and about 2 feet wide and the engine assists materially in crushing down the taller saplings. This method should be used only where the soil is of such a nature that plowing it to that depth will not

cause any injury and where the clearing operation is large enough to warrant buying such a heavy outfit.

REMOVAL OF STUMPS.

Stumps occupy valuable land; foster the growth of weeds, since in order to keep the land in their vicinity clean much hard labor is necessary; mar the appearance of otherwise smooth fields, and hence reduce the selling price of a farm; furnish shelter for harmful insects and animals; and prevent the efficient use of modern machinery.

Stumps may be removed by burning, by explosives, by mechanical means, or by a combination of any or all these three methods. There is no "best method" of ridding land of stumps, and the selection of a method for their removal should be determined only after a consideration of factors involved.

Most hardwoods decay so that they can easily be removed within 10 years from the time of logging, provided the stumps are kept from sprouting. Most pine and fir stumps, on the other hand, are very resistant to decay. Their main roots will remain sound a lifetime. The small roots of any stump will decay in a few years and with them out of the way the cost of stumping is reduced.

Often it is best to stump the field partially rather than to attempt to get all the stumps out at one time. For instance, in a field where there are a few very large stumps scattered about and many smaller ones, it might be advisable at first to remove only the smaller ones. Sometimes just by the removal of a few troublesome stumps that obstruct the way one can do fair work in cultivating a stump field.

It is usually considered more expensive to remove a stump that has burned to the surface of the ground than a similar sound stump. In order to pull such a burned stump it is necessary to dig the earth away in order to attach the pulling cables, or if a root hook is used considerable time will be lost in getting each root separately. If a burned stump is to be removed by dynamite, several charges will be necessary. With the unburned stump a single charge of explosive is usually sufficient to shoot it clear of the ground or to crack it so that it can be removed with a puller.

It also requires less power to pull a portion of a stump with a sound top than a similar portion without such a top, because of the greater leverage which can be obtained by hitching at the top. When the top of a stump is decayed and the roots are still sound, it is as hard to remove as one burned to the ground.

Tap-rooted stumps that can not be burned in the ground may be pulled entire or shattered with dynamite and pulled, or else blasted clear of the ground by explosives. If blasted, the dynamite would best be placed in a hole bored in the tap root. When an electric blasting outfit is used good work can be done by placing charges on opposite sides of the tap root and firing simultaneously.

BURNING STUMPS IN THE GROUND.

Destroying stumps by means of burning has been practiced from the time the first settlers in this country started to clear the land. One advantage of burning stumps where they stand is that there is no unwieldy stump left to handle after the operation is completed. It also requires practically no cash outlay and can be done by comparatively unskilled labor. Most of the land clearing is done by settlers and their families in their spare time, so the amount of time required to burn the stumps is not an important factor for them to consider.

The objections to all burning methods are the large amount of hand labor required and the fact that it is generally rather difficult to burn the roots below plow depth. In some fields cleared by burning methods, the roots are so near the surface that it is impossible to plow without striking many solid roots. The owners of these fields say that they would rather work a field with the stumps where they can see them than to have the ends of the big roots hidden just beneath the surface. However, it is always possible to burn all of the roots below plow depth if one is willing to take the necessary pains.

When burning stumps it is well to bear in mind that most stumps stand on a slight elevation of ground and that when the land is leveled the roots might be at the surface where previously they were even a foot below ground. Therefore the roots should be burned considerably deeper than one ever expects to plow. The writer once visited a tract where the stumps were being burned as described below in the two-hole method to a depth of 18 inches. The contract price for burning was 10 cents per stump and the owner measured the depth to which each stump was burned and did not pay unless the stump was consumed to that depth.

The following methods have all been successfully used in various parts of the country:

Two-hole method.—The following method is very effective for seasoned longleaf pine stumps of the South: Two holes are dug on opposite sides of the stump down the taproot to a depth of about 30 inches. Generally connection is made at the bottom of these holes by digging away the wall of earth between them. Any adhering earth is scraped from the taproot. A fire is then started in one of these holes. In case the two holes are not connected, fires are started in each of them. There is usually sufficient fuel on the ground to keep the fires going. Some usually can be split off the stump. After a stump is burning well it requires little attention until the taproot is burned off. Most stumps can be burned thus in one or two days. Usually the small lateral roots will also be burned so that after the holes are filled the ground may be plowed without striking any roots. The burning should be done when the land is comparatively dry.

Under favorable conditions, one man is able to burn by this method about 100 stumps a week.

One-hole method.—Another method of burning that has been successfully used in the longleaf pine area of the South is to dig a hole on one side of the stump only. This should be dug at least 20 inches deep and the adhering earth on the taproot scraped off, so that the fire will come in contact with the stump. A 1½-inch or 2-inch auger hole is then bored diagonally through the stump into the hole from



FIG. 4.—Burning a longleaf pine stump as described under Dynamite method. This stump is 22 inches in diameter and was cracked by the use of one-half pound of 40 per cent dynamite. The soil was slightly heavier here than is usually found in longleaf pine land, and it was found unnecessary to dig as deep a trench around the stump in order to induce burning to below plow depth as in places where the soil is sandy.

a few inches beneath the surface of the ground on the opposite side of the stump. A fire is then started in the excavation and the auger hole serves as a flue. After a fire is well started the stump usually requires very little further attention.¹

Dynamite method.—This method is used for burning the longleaf pine of the South and could be used for the yellow pine of the Mountain States. It is often successful where the two- or one-hole methods have failed. A trench about 8 inches deep is dug entirely around the stump. A 1½-inch hole is then bored, starting near the

¹ A hand-operated boring machine that does effective work is described in "Clearing Pine Lands," Mississippi Experiment Station Bulletin No. 159, Agricultural College, Mississippi.

bottom of the trench and extending downward at an angle of about 45° , slightly past the center of the taproot of the stump. In this hole a small amount of dynamite is tamped and exploded. The dynamite is used simply to crack the stump (fig. 4). From one-half to a whole stick (one-quarter to one-half pound) is sufficient to crack a 20-inch stump so that after a fire has been started in the trench it will burn without further attention to slightly below the bottom of the trench. The hole in the taproot may be bored with a hand auger or by means of a hand boring machine.

Cross-hole method.—This method has been more largely used in the Northwest than in any other region. A hole is bored horizontally into the base of the stump to a point a little beyond the center. Another hole is started as high up on the side of the stump as possible and bored downward at an angle until it meets the hole first bored. A fire is started at the intersection of these holes by the use of oil, pitch, coals, or by dropping a hot iron attached to wire into the hole. The fire is kept going at first by the use of a small hand bellows. The fire is kept confined in the stump as long as possible and when it breaks out logs and trash are added. By this method the top of the stump can be burned and the large roots burned a short distance below the surface of the ground. The roots can then be burned slightly further into the ground by digging the earth from around them and boring into them, or also by simply adding plenty of fuel after the earth is dug away. Often the roots are bored and then shattered by exploding dynamite in the bored holes. Sometimes the roots are blasted out by shooting each one separately. The electric blasting machine is best for this purpose. Some pull the roots by means of a stump puller, or blocks and line. There is a great temptation to stop burning before the roots are consumed below plow depth. This method requires much hand labor and a considerable amount of fuel. Sometimes the upper hole is started at the top of the stump and bored vertically downward through the center of the stump to a depth of a foot or more below the surface of the ground.

Northwest method.—This method is used principally in the Northwest. A small charge of explosive is set off under the stump. This should be just enough to crack the stump (fig. 5). The cavity underneath is then enlarged somewhat, some earth is dug away from the larger roots, plenty of fuel thrown in and a fire started. The burning is kept up as long as possible. Any roots remaining above the plow line are removed as described under the cross-hole method. Less hand labor is required than for the cross-hole method, and the roots are consumed to a greater depth.

Decapitation method.—The top of the stump is sawed off at the surface of the ground and lifted a few inches on blocks or stones.

After the stump is thoroughly dry a fire is started in the center of the stump and covered up with earth for charpitting. (See Charpitting.) As the burning continues the top settles down so that both parts of the stump are in close contact and do not allow the fire to cool. The Idaho Experiment Station¹ reports that "The stump will continue to burn slowly until the roots are practically all consumed if the land is not too sandy. This is one of the best and cheapest methods for removing stumps of red fir and yellow and white pine; it is somewhat more difficult to fire other species by this method, yet it can



FIG. 5.—This stump was cracked for burning as described under the Northwest method. Six and one-half pounds of dynamite were required.

be done." This method has been used in other sections with less success than in Idaho, the principal objection being that the roots of the stumps are not burned below plow depth.

Charpitting.—A method of burning that has been successfully used with fir stumps in clay soil in the Pacific Northwest is known as charpitting. In the spring, when the ground is soft, a shallow excavation is made between two large roots close to the stump and the bark is removed from the base of the stumps and the roots. In the summer when the stumps are thoroughly dried a large armful of wood is thrown into the excavation and fired. After the fire is well started it is covered with earth to a depth of 2 or 3 inches, care

¹ "Methods of Clearing Logged-Off Land," Idaho Experiment Station Bulletin No. 91, University of Idaho, Moscow, Idaho.

being taken that the earth does not put out the fire, and yet covers the fire well enough to confine most of the heat. As the stumps burn new covering is added each day to keep the fire covered at all times, thus retaining the heat. Stumps require considerable attention the first two or three days, but after that they need to be visited only twice a day. Most stumps will be burned up in two weeks, though some will burn for two months before being consumed. It is important not to allow the fire to go out, because it is rather difficult to start it again. Often, instead of excavating between two roots, a ring of wood is put around the stump, covered with ferns to keep the earth from sifting through and all the wood is covered with earth except a small opening where the fire is started. By this method a stump may be burned out more quickly than if fired at one point, but considerably more fuel is required. To be sure of success with the charpit method the soil must be of such a texture that when heated it will bake instead of crumble. The stumps must contain enough pitch to burn well, the season must be such that the stumps are dry when the work is started, and there must be very little rain during the period of burning. Attention to covering the fires at the right time is equally important. Under favorable conditions where a large number of stumps are burned at one time, it has taken about two hours of labor per stump to burn out the average 36-inch fir stump.

Air-blast method.—Several devices have been put on the market to accelerate the burning of stumps by means of supplying blasts of air to the fire. Some have attachments to spray oil into the flames at the time of burning. The operators of these outfits have found it very difficult to burn the roots below plow depth. It has been found possible to burn stumps by this method, but the process was so slow and costly that it has been practically abandoned.

Hood method.—Burning stumps by covering them with a hood has been used to a very limited extent for about 50 years. About 20 patents have been issued to inventors of these devices. These hoods are not in general use because of their high initial cost and comparatively short life, the great number required to do a piece of clearing owing to the slowness of burning, the difficulty of handling them, and, the most serious objection of all, the fact that by their use it is very difficult to burn the roots beneath the surface of the ground. In order to burn the roots it is necessary to dig the earth away from them to as great a depth as it is desired to burn them. This is a slow, laborious process. It seems to be as easy to burn out a stump by any of the previously-described methods as it is to use a hood in combination with them. If a hood could be constructed of such material that the radiation of heat generated within could be largely prevented, and yet be durable and not too expensive, it might be successful.

EXPLOSIVES.

Explosives can be used to advantage in clearing most land. Either alone or in combination with burning methods or pullers, explosives, if used efficiently, will materially reduce the cost of stumping.

Dynamite is a means of rapid clearing, and when it is used there is no capital tied up in idle machinery after the clearing is completed. If it is not possible to reduce the acre cost for stumping machinery to a reasonable figure, blasting is the most economical method, except perhaps the burning methods, to use in stumping small tracts. If in doubt whether to use dynamite alone in stumping it is advisable to get a 25 or 50 pound box and experiment to find how much it requires to blow out some average stumps on the tract. However, it is usually found more economical to use dynamite than to depend upon labor for doing the work.

It is difficult to clear the earth from the roots of stumps in clay soil. Where stumps are shot clear of the ground there is less adhering earth than where they are cracked and pulled. Perhaps in clay soil it would be more economical to shoot the stumps clear of the ground.

If explosives are bought in small quantities the cost is rather high. To reduce the cost it is recommended that several farmers club together and buy in large quantities. Careful, experienced persons can safely do the work with high explosives, but no one should attempt to use them until he thoroughly understands the best and safest methods of handling. Various brands of explosive require different methods of handling, and full and detailed information as to the best ways of using them is absolutely essential. For this reason, the reader is advised to study with extreme care the instructions issued by the manufacturer of the brand of explosive which he proposes to use.¹ If dynamite is to be handled in cold weather, study very carefully the manufacturers' instructions on thawing dynamite. Many accidents have happened through ignorance or carelessness in thawing. The blasting caps are much more sensitive than the dynamite itself, and should be handled with great care. A cap crimper is an inexpensive tool, and its use may prevent serious accidents.

The best time to blast stumps is when the ground is saturated with water. The explosive works most efficiently then because the gases resulting from the explosion do not escape through the spaces be-

¹ The following State publications give some information on the use of dynamite:

"Blowing Stumps with Dynamite," Kentucky Agricultural Experiment Station Bulletin No. 154, Lexington, Ky.

"Land Clearing," Minnesota Agricultural Experiment Station Bulletin No. 134, University Farm, St. Paul, Minn.

"Investigations in Costs and Methods of Clearing Land," Minnesota Agricultural Experiment Station Bulletin No. 163, University Farm, St. Paul, Minn.

"Methods of Clearing Logged-Off Lands," Washington Experiment Station Bulletin No. 101, Pullman, Wash.

"Use of Explosives in Clearing Land," Wisconsin Experiment Station Bulletin No. 216, Madison, Wis.

tween the soil particles, and the roots of the stumps will slip out of the earth easily.

An explosive containing a low percentage of nitroglycerin will do the same work in wet soil as one containing a higher percentage would do in the same soil when dry. Dynamite with 20 per cent of nitroglycerin or its equivalent is used almost exclusively on the Pacific coast. It could be used effectively for stumping operations in many other parts of the United States, especially where the soil is heavy, wet, or where the stumps are well decayed. Dynamite with 40 per cent nitroglycerin is largely used in the South for blasting the longleaf pine, and in the Lake States for white pine. In many cases a lower grade of explosive could be profitably substituted. The 40 per cent grade should be used where the soil is somewhat light and dry or where the stumps are green. The 60 per cent grade of dynamite has been used with good success in blasting stumps in the porous coral soils of southern Florida, in blasting stumps at a dry time in sandy soil, and in blasting tough, green, hardwood stumps. The higher percentage dynamites are likely to pack heavy soil if used when it is very wet.

Roughly, the number of pounds of dynamite required to shoot a stump clear of the ground is the same as the square of the number of feet in the diameter of the stump at the cut-off. For example, a 2-foot stump will require 4 pounds, and one 6 feet in diameter will require 36 pounds. Often less will do the work, but occasionally more is required. All factors, such as kind and soundness of the stumps, and kind and condition of the soil, influence the amount of explosive required for a stump of given size. Loud reports and the throwing of parts of the stump high in the air indicate an excessive charge.

Firing charges by electricity.—The electrical method of firing blasts is beginning to be extensively used. In firing charges by this method the following equipment is needed: One blasting machine, 300 feet of double leading wire to reach from the stumps to the blasting machine, some connecting wire to connect the stumps together in a series, and electric detonators in place of the caps and fuses used in ordinary blasting. Firing by electricity has many advantages over the cap and fuse method. The danger of premature explosions is greatly reduced, and the danger from delayed explosions is entirely eliminated. Probably more people have been injured in stump blasting by too hasty investigation of a delayed explosion than from any other cause. When using the cap and fuse method, the safe rule to follow when a charge does not explode as expected is to keep away from the locality until the next day. Where the stumps have been severely burned, are badly decayed, hollow, have several large spreading roots, or where it is necessary to blast

stumps so near to each other that the explosion of a charge under one stump would loosen the earth under the adjacent one, the use of the blasting machine will save dynamite and result in better work being done than if the cap and fuse are used. If the stumps have been partially burned out by any of the burning processes previously described, the roots can best be blown out by firing the charges with a blasting machine.

STUMP PULLERS.

As a rule, the farmer who is clearing land has little ready money to spend. The method that appeals to him most is one that requires a minimum cash outlay for explosives, is fairly rapid and effective, and will permit the use of teams and family labor. For clearing small areas the economy of buying a stump puller is questionable. From one-fifth to one-half the explosive required to shoot a stump clear of the ground will break it up so that it may easily be pulled by the use of a stump puller. However, stump pullers are expensive, some of the good ones, complete, costing \$200 or more. Now suppose, for example, that trials indicated that it would require 40 cents less for dynamite to crack the stump so it could be pulled by the use of a puller, than it would to shoot it clear of the ground, and a count showed that 500 stumps were to be pulled. It is obvious that it would not be economy to pay more than \$200 for a puller unless one were sure of selling it at a good price after completing the work.

Several ways have been suggested for lowering the acre charge for use of the stump puller. Often secondhand machines can be purchased or hired cheaply. Sometimes one can sell a puller at a fair price when it is no longer needed. Several farmers might purchase one in partnership. Commercial clubs, townships, or county officials interested in the development of cut-over lands could purchase such an outfit and rent it to those clearing land. Probably \$2 a day rental, with the understanding that the party renting would be responsible for any damage and for losses of chokers or small parts, would be a fair charge.

Most manufacturers of stump pullers furnish detailed instructions for operating their machines, and illustrations of various time- and labor-saving methods of making hitches, so little attempt has been made in this publication to go into detail concerning these points. Only a general discussion of the types of pullers is given in the following pages.

There are two general types of stump pullers, those that pull the stump from the side and those that lift it vertically out of the ground. The capstan pullers pull from the side. Most of the horsepower and some hand-power machines are of this type. All steam and gasoline power outfits pull from the side. The tripod machines lift the stump

vertically. These are mostly horsepower machines, though there are some hand-power tripod machines.

CAPSTAN STUMP PULLERS.

With the capstan type of puller, an acre or more of stumps can be pulled at a single setting (fig. 6). This feature saves considerable time and makes the capstan type efficient for pulling small stumps like scrub oak, jack pine, alder, and others. Where small, sound stumps are pulled, considerable time is saved by using cluster ropes



FIG. 6.—Pulling white pine stumps by means of a capstan puller. If these stumps had been shattered by dynamite before pulling, less earth would have adhered to the roots.

and cable take-ups. In getting scattered roots or stumps where the tops are burned off, it is advisable to use a good root hook which will largely obviate the necessity of digging out each root before the cable can be hitched to it.

The capstan machine will work on steeper land than the tripod, though no horsepower machine will do very efficient work on a steep hillside. In stumping hilly land set the capstan as near the anchor stump as possible and place the anchor cable in notches cut at the ground line of the anchor stump. By using the double and triple power arrangements of lines, the capstan machines will pull very large stumps.

It is becoming the practice, however, in most sections to split all the largest stumps by means of dynamite rather than to attempt

to pull them by the use of extra power blocks and cable. This does away with adjusting blocks and hauling extra cable, reduction in speed of pulling, and the difficulty of disposing of the large stumps. Also the use of dynamite will shake the stump sufficiently so that the earth may be quite easily removed from the roots. Most farmers, however, will need extra blocks and cable for some cases where poorly placed charges of dynamite have not loosened the stump sufficiently so that it may be pulled whole or in pieces by direct pull.

Medium-sized machines are usually more satisfactory than large ones, since the latter are cumbersome to handle and are expensive. Three men and a team make a good working crew in operating one of the capstan machines.

Horsepower capstan stump pullers cost complete from \$75 to over \$250. If they are given average care there should be very little expense for repairs to the machine. The cables will wear out before the machine, but with proper care should last as long as the average farmer would need them to clear his land. Kinking the cable, or breaking the strands by running through small blocks, or cutting it by improper hooking causes it to wear out rapidly. Using the puller when it is wet causes the cable to rust and dragging it through the mud grinds the cables.

Plow-steel cable is generally used for pulling stumps. The $\frac{3}{4}$ -inch cable has a working strain of 5 tons; the $\frac{7}{8}$ -inch cable, 6.8 tons; and the 1-inch cable, 8.8 tons. The breaking strain is five times the working strain. The $\frac{3}{4}$ -inch and $\frac{7}{8}$ -inch cables are most extensively used.

TRIPOD STUMP PULLERS.

The tripod stump puller (fig. 7) has been quite extensively used for pulling large scattering white and Norway pine stumps growing in sandy soil in Michigan.¹ They are also used, to a limited extent, in the Mountain and Pacific Coast States and in some parts of the South. They have proved to be a very satisfactory puller for use in the Lake States. There are three patterns, screw, windlass, and lever machines. The lever machines are most widely used. Any stump is pulled more easily when lifted vertically than when pulled from the side. No anchor stump is required for this type. The puller is moved for each stump, as it is necessary to set the machine directly over the stump to be pulled. The stump is lifted by chains passed around one of the larger roots. The tripod types of vertical lift machines are very powerful, and in Michigan few contractors ever use dynamite to assist in pulling. It is well to keep in mind, however, that in most cases where the tripod has been used the soil was so

¹ For more details concerning these pullers see "Costs and Methods of Clearing Land in the Lake States," U. S. Department of Agriculture Bulletin No. 91. For sale by the Superintendent of Documents, Government Printing Office, Washington, D. C. Price, 5 cents.

sandy that the adhering earth could be easily cleaned from the roots of the stump.

Pulling a stump with a tripod machine leaves practically no hole to be filled, because the earth when cleaned from the roots of the stump falls into the hole made by the removal of the stump. Four men with four horses make a good working crew. Data have been secured showing that on five tracts of land the crews averaged 79 stumps per day for over 140 days.



FIG. 7.—A tripod stump puller. This crew pulled and cleaned an average of 15 stumps a day. No dynamite was used. The stump is a white pine. The soil is a light sandy loam. This tract has been logged 45 years. The roots were used for fuel. Most of the tripod pullers are mounted on skids and are handled by a crew of four men and four horses.

When pulling stumps growing in heavy soil with these outfits it is advisable to crack the stump with dynamite before pulling, because it very greatly reduces the amount of labor required to clean the earth from the roots.

The tripod machines cost from \$125 to \$200. The screw machines are very durable. The cables of the windlass and lever machines will break in time, but otherwise there should be but little expense for repairs. The manufacturer of one of the lever machines states that on the average a cable will last to pull 6,000 stumps before wearing out.

HAND STUMP PULLERS.

There are two types of these machines, one of which pulls the stump from the side and the other of which lifts the stump like the tripod horsepower pullers. The hand stump pullers usually cost less than the horsepower pullers. While it is possible for one man to operate them, two men can do more efficient work than one.

In pulling standing trees or in pulling stumps in locations where logs, tree tops, or other obstacles would prevent the use of the horse machine, the hand stump puller is very efficient (fig. 8). It also has an advantage over the horsepower puller in that it can be operated



FIG. 8.—Pulling a second-growth fir stump by means of a hand stump puller.

in almost any position, while the pull of the latter machine must be in a nearly horizontal position, otherwise it is likely to be overturned. For that reason hand stump pullers can be operated on very steep land and less time is required to set them up than to set up horse machines.

With all of the hand stump pullers speed must be sacrificed for power. Even then it is necessary to use blocks and cable when pulling large stumps, and besides making the operation of the machine much slower, the adjustment of blocks and cable takes much time. In order to pull a stump without the use of extra blocks and cable it is necessary to shatter it well with dynamite.

The more slowly a stump is extracted from the ground the less the roots are broken off in the ground. For that reason one is likely to

leave fewer roots where a hand puller is used than where a donkey engine or dynamite is employed.

As a general proposition, horsepower is cheaper than man labor. Where a horsepower machine can be used, stumps can be pulled more cheaply by it than by a hand-power machine. Most farmers who are stumping land have teams, and instead of allowing them to stand idle and hiring laborers to do the work of stumping, it is economy to use the horses. The hand stump pullers cost from \$30 to about \$200.

BLOCKS AND LINE.

Blocks and line can generally be used to good advantage wherever hand, horsepower, capstan, or tripod machines would be employed. When tackle is used for heavy clearing it is necessary to use somewhat more dynamite than when using any one of the other pullers. Blocks and tackle come in handy where dynamite is used, because in all such stumping operations there are usually some shots that do not remove the whole stump, or that leave in the ground some roots that are too solid to be removed by a team with a direct pull. In clearing swampy ground where the rooting system of the trees is very shallow, blocks and lines with a good team make a very satisfactory device for removing stumps. Usually stumps can be pulled more rapidly with blocks and lines than with a stump puller, though, as indicated above, more dynamite is needed to shatter the larger stumps.

Arrangements from a single block and line to a combination of two triple blocks are used. When the line of pull is parallel to the line of resistance one single block with line will increase the power twice; two single blocks, three times; one single and one double block, four times; two double blocks, five times; and two triple blocks, seven times. A good way to use several single blocks is to connect them in series, one after another. In this case each block may have a separate anchor. By this arrangement one single block (as before) increases the power twice; two single blocks, four times; and three single blocks, eight times. This arrangement gives greater efficiency than the one previously mentioned because there is less loss through friction, though it is more trouble to connect the lines in this manner, and heavier lines are needed.

Single blocks suitable for pulling stumps should not cost much over \$2 each and triple blocks \$4 each. Half-inch plow-steel cable, which has a working strain of 2.3 tons and costs about 12 cents a foot, is often used for line. Sometimes $\frac{3}{8}$ -inch and occasionally $\frac{1}{2}$ -inch cable is used. Ordinarily the blocks should be at least 10 feet apart when starting to pull. In this case when using triple blocks, about 80 feet of cable would be required. In addition to this, two pieces of $\frac{3}{4}$ -inch cable will be needed, one about 10 feet long for a "choker," and the other 40 or 50 feet long to use for the anchor. This cable

should not cost over 25 cents a foot. Where one single block is used, 50 or 60 feet of $\frac{1}{2}$ -inch or $\frac{3}{8}$ -inch cable, with 10 feet of choker cable, which can be of the same size, will be all that is required. Hooks and eyes will be required on the cables.

The cost of tackle complete will range from \$15 to \$40, new. In case it is desired to use rope instead of steel cable, use nothing lighter than hemp rope 1 inch in diameter.

Blocks and tackle suitable for pulling stumps cost much less than stump pullers, and after the land is cleared they will be found handy for many other operations about the farm. Often secondhand elevator or logging cable and blocks, fit for use in pulling stumps, can be purchased cheaply of junk dealers.

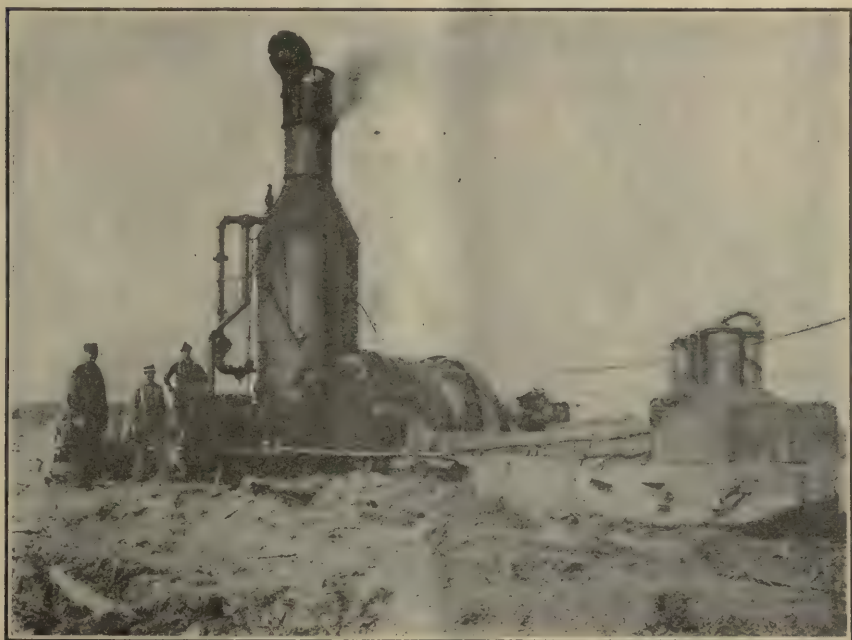


FIG. 9.—A powerful steam donkey engine used in land clearing.

In a test of blasting white-pine stumps in fairly wet sandy-loam soil in Michigan, it was found (figuring dynamite at \$12.75 per 100 pounds and electric detonators at \$4.70 per 100) that it cost 22 cents more to shoot clear of the ground the average stump 23 inches in diameter at the cut-off than to shoot it so that the pieces could be pulled by a team with block and line. Thus, a farmer with his team and equipment and hired man could earn \$6.50 a day, in dynamite saved, if they pulled the pieces of 30 stumps a day.

In the test just described about 3 pounds of explosive was used to shoot the stumps clear of the ground and $1\frac{1}{2}$ pounds to split them for pulling with team, blocks, and line. If the same work had been done on heavy soil the difference in cost between the two methods would

not have been so great, because less explosive would have been used and more work would have been required to clean the earth from the roots of the stumps pulled by the block-and-line method.

STEAM AND GASOLINE POWER OUTFITS.¹

Power stump pullers have been used to a limited extent in the Lake States and in the longleaf pine regions of the South. A few machines have been successfully used in the bottom lands of Missouri and Arkansas. There they have been employed principally to pile worthless logs and small growth rather than to pull stumps. Some

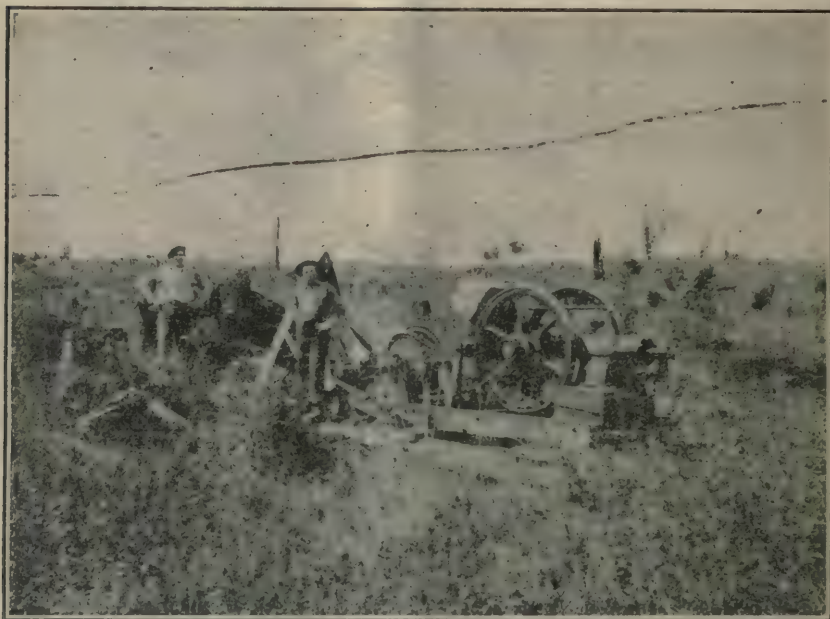


FIG. 10.—A small gasoline donkey engine used in pulling stumps.

of the steam donkeys (fig. 9) used for stumping have been especially designed for this work, but most of the clearing has been done with logging engines. The ordinary hoisting donkey engine has not been successfully used in this work. The most extensive use of donkey engines has been in the Puget Sound region. Here they have proved to be a cheap and successful method of clearing logged-off lands, especially those where there was a great amount of worthless logs and trash to be removed from the lands. It is necessary to use explosives in connection with these machines, since they have no greater pull than a good stump puller (fig. 10). The cost of these power outfits, however, is so great that they are beyond the reach of the average settler.

¹ For details of operation of these engines see "Costs and Methods of Clearing Land in Western Washington," Bureau of Plant Industry Bulletin No. 239; for sale by the Superintendent of Documents, Government Printing Office, Washington, D. C. Price, 10 cents.

Sometimes it is possible for a group of settlers to hire one of these outfits and exchange labor in clearing. Where this is possible, and they have a good engineer and a good man in the field to direct the work, they can do the work in a very rapid and efficient manner.

Some gasoline outfits are in use. They require about the same sized crew as a capstan stump puller, and with a good outfit efficient work can be done.

TRACTION ENGINES.

Traction engines or gas tractors have been used in a few places in various parts of the United States for clearing land. They have proved to be successful in removing small growth and well-blasted stumps.

If there is a probability that a tractor could be used with profit on the land after clearing, it would in many cases be advisable to purchase such an outfit at the beginning of the clearing operations. Usually the growth or stumps are removed by a direct pull. A chain or cable may be used for this work.

DISPOSAL OF STUMPS AFTER PULLING.

All pine stumps are rich in pitch and make excellent fuel. In many areas one could use the larger part of stumps for fuel.

On many farms there are deep gullies adjacent to the newly stumped fields and the stumps could be used to fill these. Adjacent to other fields are waste places which are worthless for farming and to which the stumps could easily be hauled. In the Lake States in the early days of clearing, many fences were made of pine stumps, but few such fences are being built at the present time. Where stumps have been well blasted it is relatively easy to handle them. In some sections the practice is to start small fires in the holes made by blasting stumps and then haul the pieces to these fires. This is considered cheaper than it is to build a few large piles and not set them on fire until all the stumps are piled. Large stumps are very hard to pile.

Sometimes when white-pine stumps have been pulled whole by means of powerful pullers they are split by blasting. A small charge of dynamite is placed either in a hole bored into the base of the stump or in a notch chopped between two prominent roots. When placed between the roots, cover with earth the same as for mud capping boulders. Often the heart of the stump is sufficiently decayed so that a charge may be placed in it. A small quantity of dynamite used in this manner will usually split the stump as well as a much larger charge would have done before the stump was pulled.

Where it is the plan not to pile the stumps within six months after pulling, it might be economical not to clean them when pulling, because during that period much of the earth will wash from the roots. Some pull the stumps in the fall and do not clean them until the following spring. It will be necessary, however, to clean the earth at the time of pulling from stumps pulled by a tripod machine.

Where stumps are hauled into big piles, it is important that they be free of earth. It has happened, especially where donkey engines have been used for piling, that so much dirt was hauled to the pile with the stumps that it was almost impossible to burn them, and after they were finally burned a big heap of earth was left to be hauled away.

A good method of piling is to use a piler with a swinging boom as shown in fig. 11. The mast of this piler is 30 feet high and the boom is 25 feet long. Using a gin pole, as shown in fig. 12, is a good plan. A few pilers have been made with a mast and boom constructed of iron pipe mounted on a wooden platform. In operating



FIG. 11.—Piling stumps by means of a swinging boom piler. Using this outfit, four men with three teams piled and burned an average of 51 white pine stumps a day for 20 days. Dynamite was used under some of the largest stumps, 200 pounds being required on this 50-acre tract where 1,018 stumps were disposed of. A capstan puller with a crew of 3 men and a team was used in pulling, and averaged 23 a day.

this piler it can be hauled to a convenient place in the field, anchored, and earth thrown upon the frame to keep it from catching fire. A fire is built and the stumps hauled and deposited on the fire. The piling is continued while the fire is burning. This method has proved a very satisfactory one. Piling and burning at the same time can be carried on with a wooden piler, but there is danger of its catching fire. The work of piling stumps could be hastened materially by using some tripping device which would not necessitate the presence of a man on the stump pile. With some of the best donkey-engine outfits self-releasing chokers have been used. Hauling stumps to the piles can best be done when the ground is frozen hard. Loading on to a stone boat and hauling is a good way. Blocks and lines are useful in this work.

SOFTWOOD DISTILLATION PRODUCTS FROM STUMPS.

Many experiments have been made to reduce the stump by means of destructive distillation before it has been removed from the ground, but to date none of these methods has been successful. It has been found that the fir stump of the Northwest and the Norway pine of the Lake States yield too little of the products of softwood distillation such as turpentine, pine oil, tar, etc., to make their extraction commercially profitable. Longleaf pine stumps of the South



FIG. 12.—Pile of stumps and logs around a gin pole. These were piled by means of a donkey engine. The gin-pole method of piling could be used with a team.

yield large quantities of products which have been found valuable for numerous purposes. A number of plants of several different types have operated continuously in the South for many years; others have, from one cause or another, failed. When the price of turpentine goes below 40 cents a gallon and the price of rosin below \$4 a barrel, the wood-distillation plants making these articles alone are usually forced to close. As the acreage of longleaf pine timber available for turpentering decreases, it is likely that there will be an increase in this industry. Only a small percentage of the farmers of the South, however, can hope to dispose of their pine stumps for distillation, because their lands are located too far from the distillation plants. Western yellow pine also contains valuable products, but as yet very little effort has been made to extract them in a commercial way.

Boring and blasting have been extensively used in getting stumps out of the ground for distillation. To get the best results when

blasting taprooted stumps, the charge must be placed within the taproot. To do this, a hole of sufficient size and deep enough to place the explosive at the center must be bored into the stump. The hole should be bored so deep that the center of the charge will be at or near the center of the taproot. (Fig. 13.) The hole should be started into the stump from about 10 inches below the surface (deeper if the stumps are to be used for distillation) and should slant downward at an angle of about 45°. Boring these holes by hand with a 1½-inch or 1½-inch auger is heavy work. In some cases, when a ship auger is used, it will require two men.

Several turpentine companies who are using the stumps of the longleaf pine for distillation purposes have assembled outfits for boring these holes by means of electric drills, with power supplied

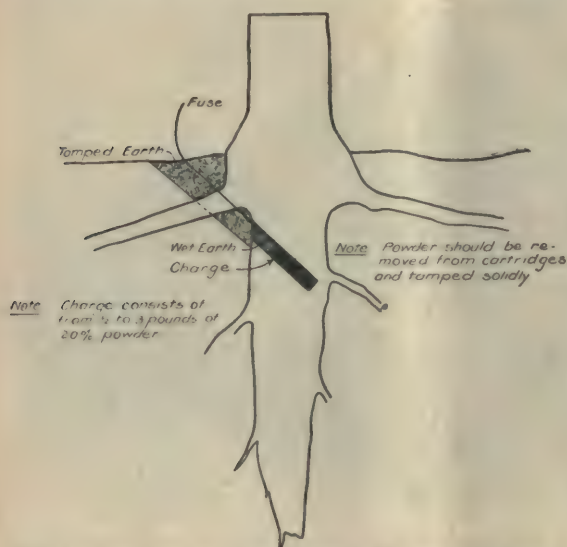


FIG. 13.—Diagram showing a section of a taprooted stump and a charge in position for blasting.

by a dynamo run by a gasoline engine and mounted upon a wagon. It requires a crew of six to run this boring machine. They can bore from 300 to 500 stumps in a day. When operated continuously, the average cost per stump for the holes drilled will be about 3 cents. This cost takes into account repairs, depreciation, and interest, as well as operating expenses. An outfit of this kind could be

utilized for boring the stumps for burning as described under the one-hole or dynamite methods (p. 11). However, these outfits cost at least \$500 each (probably more under present abnormal conditions), and hence they are beyond the reach of the average farmer. It has been found that the taproot, to a depth of about 30 inches, is quite as rich in valuable products as any part of the stump above ground. In order to remove the taproot to that depth by means of the boring and blasting method it is necessary to start the auger hole considerably more than 10 inches deep, which is deep enough for ordinary clearing.

Stump pullers and steam-power outfits have been used in pulling these stumps. With pullers all of the taproots can be obtained.

Where pullers are used it is advisable to split the stumps into pieces with dynamite so that they can be handled. Probably the 40 per cent dynamite is most often used, but some report that they prefer the 60 per cent grade for this purpose.

CHEMICALS WORTHLESS FOR REMOVING STUMPS.

So far as we have been able to learn, all experiments conducted to determine the value of sulphuric or nitric acid, either alone or combined, saltpeter, or nitrate of soda, as a means of destroying, or as an aid in burning stumps, have clearly demonstrated that these chemicals are worthless for this purpose.

BURNING LOGS.

Often logs are burned into desired lengths by boring a horizontal hole into the side and a vertical intersecting hole from the top. Coals are used to light a fire at the intersection of these holes. To split the log so it will be entirely burned, bore into the side and load with dynamite. Some bore from the top, but the horizontal hole is to be preferred because in the first case the force of the explosion separates the halves, while in the second the upper half lies close to the lower and the fire burns better. (See Decapitation Method, p. 12.)

FILLING HOLES AND DISPOSAL OF STONES.

Generally the holes made by the stump can easily be filled by the use of an ordinary two-horse walking plow and team. Where large stumps have been removed by heavy charges of dynamite the holes are so large that it may be necessary to use a scraper.

Where stones are plentiful a good method of disposing of them is to throw them into the stump holes. Burying boulders too large to move is a common practice. An excavation large enough to contain the rock and cover it about 2 feet deep is made as close to the stone as can be done with safety and the stone is rolled into it.

Sometimes a boulder can be broken by digging the earth away from it so that it will be exposed, building a good fire around it, and dashing cold water on it after it is thoroughly heated. Many rocks can be broken up by the use of a heavy sledge. Dynamite is very efficient as a means of breaking up boulders. From 40 per cent to 60 per cent strength should be used, depending upon the method and the hardness of the rock. For detailed information on blasting boulders the reader is referred to instructions issued by the manufacturers of explosives.

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Cost and Methods of Clearing Land in Western Washington. (Bureau of Plant Industry Bulletin 239.) Price, 10 cents.

THE CONTROL OF EUROPEAN FOULBROOD

E. F. PHILLIPS

Apiculturist



FARMERS' BULLETIN 975

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C.

July, 1918

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EUROPEAN FOULBROOD is a disease of the brood of bees which has caused great losses to American beekeepers. It was first recognized as a distinct disease in the United States by New York beekeepers in 1894, but it has probably been present in the United States for a long time.

It is important that the beekeeper know whether European or American foulbrood is in his apiary, for the two do not respond to the same treatment. In European foulbrood control the most important step is to prevent the entrance of the disease by keeping all colonies strong and by having all stock resistant to the disease. This can be done successfully even though the disease is in the neighborhood.

In case, through failure to take all precautions, the disease does enter, there are certain practices by which the disease can be readily eliminated, but all of these must be used with care.

The facts about the disease on which the preventive and remedial measures are based are discussed in this bulletin.

THE CONTROL OF EUROPEAN FOULBROOD.

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DIFFICULTIES OF CONTROL.

EUROPEAN FOULBROOD has caused much trouble in treatment and causes more anxiety among beekeepers than does American foulbrood. It is recognized generally that European foulbrood requires less drastic methods than does American foulbrood, but seemingly one cannot always be so sure of the efficacy of the treatment, and it is often said by beekeepers that European foulbrood "does not fight fair." The difficulty seems to lie in the fact that the course of the disease in the colony has not been sufficiently studied and the features of treatment have not been adequately analyzed. It is not enough simply to know the name of the organism which causes the disease, but it is essential to know the habits of the germ in the colony.

European foulbrood was first recognized in New York State in 1894, and previous to that time no adequate differentiation had been made between this disease and American foulbrood. Various writers, especially those in Europe, had recorded two types of brood diseases and had differentiated them sufficiently to call one mild and the other virulent. Careful observations of beekeepers, as well as bacteriological investigations, have shown that the two diseases are entirely distinct, that one does not change to the other, and that in treatment they behave differently.

Now that the symptoms of the two diseases have been carefully studied, one can examine the earlier literature and find indications that European foulbrood was rather widespread in the United States before it was recognized as a distinct disease. At any rate it appears certain that all the European foulbrood in the country did not spread from the first recognized outbreak in New York State. New York beekeepers with justice objected to the name "New York bee disease" which was at one time applied to the disease.

NAME OF THE DISEASE.

When American beekeepers first differentiated this disease the name "black brood" was generally applied to it. When the investi-

gation of bee-disease control was inaugurated by the Bureau of Entomology it was recognized that this name was not well chosen, for black is not the predominating color of the dead larvæ. If any color designation were to be used, yellow would be best, but color is not a safe guide, as this is a variable symptom. Any descriptive name seemed unsafe for a disease with such variable manifestations, and the author therefore proposed that the name be changed. After consultation with beekeepers and apiary inspectors it was decided to adopt the name European foulbrood. This was first used in a circular¹ of the Bureau of Entomology and the name has been generally accepted by beekeepers throughout the country. The adjective "European" was chosen because it appeared that this disease had first been subjected to bacteriological investigation by European investigators, while the other disease, American foulbrood, had not been investigated carefully until such work was undertaken in America. The names obviously are not intended to convey the idea that the diseases originated one in America and the other in Europe, for the honeybee is not native to America. The names were chosen simply that beekeepers might have names which could be used with safety, and which would not lead to confusion by being descriptive.

SYMPTOMS.

The beekeeper should know whether he has to deal with American or European foulbrood, for they do not respond to the same treatment. The symptoms of European foulbrood are simply the outward manifestations of the disease, being chiefly the appearance of the larvæ after death. The symptoms are therefore variable. The most accurate method of diagnosis is by bacteriological examination, but this is, of course, not possible in apiary practice. In cases of doubt samples should be sent to the Bureau of Entomology for diagnosis.²

In regions where both diseases occur, beekeepers at times experience difficulty in differentiating them, due chiefly to insufficient observation of the symptoms. If European foulbrood appears in an apiary in the spring, and if American foulbrood is then observed later, the beekeeper may erroneously conclude that both types are

¹ Phillips, E. F. The brood diseases of bees. U. S. Dept. Agr. Bur. Ent. Circ. 79. 5 p. 1906.

² If dead brood is observed and the beekeeper is not able to diagnose it with accuracy, samples may be sent the Bureau of Entomology for examination. A piece of comb containing dead larvæ about 4 by 5 inches should be cut out and mailed in a heavy pasteboard or wooden box. Tin boxes should never be used, as the brood usually molds in transit, making examination impossible. The sample should not be wrapped before being placed in the box. A suitable box for sending samples will be mailed on request.

It is not possible to diagnose from empty combs, and no honey should be included in the sample, as it is valueless in diagnosis and will probably spoil the sample as well as other mail matter. The name of the sender must always appear on the package, and any available data should be sent in a letter. Never inclose a letter in the box with the sample.

manifestations of one disease, or that European foulbrood changes to American foulbrood. Such is not the case. It is therefore essential that the symptoms be studied with great care, since to treat American foulbrood by methods applicable only to European foulbrood will result in the spread rather than in the eradication of the disease.

(1) *Age of larvæ affectea*.—European foulbrood usually attacks the larva at an early stage of its development, while it is still curled up at the base of the cell (fig. 1, R). At the time of the first manifestation of disease the larva is about three days old, from the hatching of the egg. A very small percentage of larvæ die after

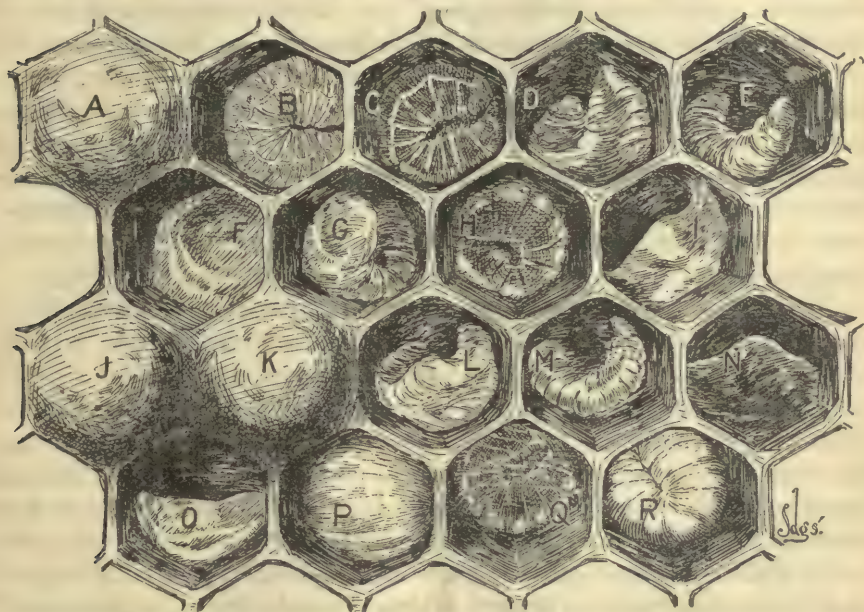


FIG. 1.—Portion of comb, showing effect of European foulbrood upon the larvæ: A, J, K, normal sealed cells; B, C, D, E, G, I, L, M, P, Q, larvæ affected by disease; R, normal larva at age attacked by disease; F, H, N, O, dried-down larvæ or scales.

capping, but sometimes quite young larvæ are attacked (fig. 1, E, M). Sunken and perforated cappings, which are such common symptoms of American foulbrood, are sometimes seen in colonies suffering with European foulbrood.

(2) *Early symptoms*.—The earliest indications of the disease are a slight yellow or gray discoloration and the uneasy movement of the larva in the cell. The larva loses its well-rounded, opaque appearance and becomes slightly translucent, so that the tracheæ may become prominent (fig. 1, B), giving the larva a clearly segmented appearance.

(3) *Position of larvæ*.—The larva may be flattened against the base of the cell, may turn so that the two ends are to the rear of the cell (fig. 1, P), or may fall away from the base (fig. 1, E, G, L). The

position of the larva is one of the best means of differentiating American foulbrood and European foulbrood. In American foulbrood the larvæ almost without exception are found on the lower side wall, while in European foulbrood they may be there, or at the base of the cell, or on any of the side walls, even the upper one.

(4) *Color*.—As the decay proceeds the color changes to a decided yellow or gray and the translucency is lost (fig. 1, Q, H). When the disease first appears in a region the yellow color of the decaying larvæ seems more constant than later, due probably to the fact that as the disease spreads the germ causing the disease is accompanied by other organisms. The yellow color may be taken as the chief characteristic of the disease. The dead larva appears as a moist, somewhat collapsed mass, giving the appearance of being melted.

(5) *Scale*.—When the remains have become almost dry (fig. 1, C), the tracheæ sometimes become conspicuous again, this time by retaining their shape, while the rest of the body content dries around them. Finally all that is left of the larva is a yellow or grayish-brown scale against the base of the cell (fig. 1, F, H), or a shapeless mass on one of the side walls if the larva did not retain its normal position before death (fig. 1, N, O). Very few scales are black.

(6) *Adhesion to cell*.—At no time during the decay does the larva adhere to the wax closely, but is easily removed, and the bees carry out a great many of them in their efforts to clean house.

(7) *Usual lack of ropiness*.—A slight ropiness is sometimes observed in the decaying larvæ. This is not, however, at all like the fine ropiness observed in larvæ dead of American foulbrood, but the decaying mass behaves more like an old rubber band which has lost its elasticity and which breaks when stretched.

(8) *Odor*.—There is usually little odor in European foulbrood, but sometimes a sour odor is present which reminds one of yeast fermentation. This odor is quite constant in some regions and seems to come from the decay due to organisms other than the one which causes European foulbrood.

(9) *Sex*.—A symptom of the greatest importance is the fact that the disease attacks drone and queen larvæ¹ nearly as quickly as those of the workers.

(10) *Epidemic character*.—In regions where the disease occurs a considerably larger percentage of colonies is affected than is usual for American foulbrood. However, not many colonies die of European foulbrood, but the chief trouble is that weakened colonies succumb during winter unless well cared for. The disease spreads at

¹ The tendency of this disease to attack queen larvæ is a serious drawback in treatment. Frequently the bees of a diseased colony attempt to supersede their queen, but the larvæ in the queen cells often die, leaving the colony hopelessly queenless. The colony is thus depleted rapidly.

times with startling rapidity, much more rapidly than American foulbrood.

(11) *Variability*.—In all its symptoms European foulbrood is more variable than is American foulbrood. Color is perhaps the most constant symptom.

BASIS OF TREATMENT.

The confusion in the treatment of the disease is due to a failure to analyze the factors forming the basis of treatment. Various treatments have been described in the beekeeping journals as distinct when they were simply modifications of the same treatment.

(1) European foulbrood is a disease of weak colonies. While at times one may observe larvæ dead of this disease in strong colonies, usually they are removed before the disease can do much harm. It should be pointed out, further, that it is the colony which is failing to increase in strength in the spring which is most seriously affected, for a small colony which is rich in young and vigorous bees and which is increasing in strength is often able to overcome the disease. It is therefore a disease of weak rather than small colonies.

(2) The disease is prevalent in the spring and early summer. While at times it is observed at other periods of the year, this is not usual. Samples of European foulbrood have been received by the Bureau of Entomology in every month of the year, but, as will be seen from Table I, they are far more commonly received in the early part of the active season. These samples are listed according to the date of receipt at the bureau laboratory. The highest number is received in June and the average date for the removal of these samples from the hives is probably a few days previous to June 15, perhaps June 10. The earliest samples received are regularly those from California, where the season opens early. There is a sudden increase in May and June and almost as rapid a decline later. The few samples received from October to April may be largely disregarded, as they are almost without exception dried material of unknown age.

TABLE I.—*Distribution of European foulbrood by months, including all positively diagnosed samples received by the Bureau of Entomology from 1906 to December, 1917.*

Month.	Total number.	California.	New York.
January.....	3	0	0
February.....	4	3	0
March.....	17	10	0
April.....	33	17	2
May.....	180	24	23
June.....	334	30	50
July.....	240	20	41
August.....	164	9	20
September.....	98	8	8
October.....	17	1	3
November.....	7	3	1
December.....	2	1	0

(3) The disease disappears later in the summer unless the colony has become so badly weakened that it can not remove the dead larvæ. Such weakened colonies usually die in winter or in a time of dearth. Colonies do not as a rule die as a direct result of European foulbrood. There may still remain some dead larvæ in the combs, showing that the bees have not been able to remove all of them, but in any but the worst cases even these disappear. If conditions which commonly prevail in early summer again appear there may be a recurrence of the disease the same season.

(4) This disappearance of the disease usually accompanies the beginning of the honey flow. At this time, unless the colony has already reached maximum strength, there is a rapid increase in brood rearing and the colony increases in strength, bringing about conditions unfavorable for the development of the disease. If the honey flow fails, the disease may continue and under such conditions is at its worst. It should be noted that in regions where the early honey flows are uncertain or usually lacking European foulbrood has done the most damage, for in years of failure the disease spreads with such rapidity that the entire region becomes badly infected. European foulbrood is rarely observed in regions where an early honey flow is certain.

(5) The earliest brood of the year usually escapes with little loss. This important fact has been overlooked in previous discussions of this disease, but it is evident from Table I. The scarcity of European foulbrood in the early spring was mentioned in the earliest accounts of its prevalence in New York. This in all probability is due to the fact that the colonies have been able to remove most of the disease during the previous summer and there has been left only a little of the infecting material.

(6) Some bees resist the disease more successfully than others. It has been found through the experience of beekeepers generally that the three-banded Italian bees are best for this purpose. These bees have a further advantage in that they give excellent results in all lines of beekeeping activity, and it is therefore safe to recommend them as the best. This does not at all indicate that other races of bees would not give as good results, as far as European foulbrood control is concerned, but that it is easier to get good three-banded Italian than good bees of any other race. The resistance appears to be either a form of immunity or a greater ability to remove the dead larvæ completely.

(7) European foulbrood is an infectious disease. This was clearly shown by the experience of beekeepers before the disease was investigated from a bacteriological standpoint, and these investigations have supported the observations of the beekeeper. The bacteriological

work has shown, further, that the disease is caused by an organism¹ which has never been found in any other brood disease of bees. The cause of the disease is, therefore, a specific organism, and the disease is entirely distinct from American foulbrood. This is an important point, for there has in the past been considerable confusion in that a few beekeepers have claimed that one disease changes to the other. It should be made clear that this supposition is not supported by any careful observation in the apiary, and that it was recognized generally by beekeepers before the bacteriological investigations were made that the diseases were distinct.

(8) The organism causing European foulbrood does not seem from observations in the apiary to be so difficult to eradicate as does the one causing American foulbrood. This is partially confirmed by the bacteriological observations also.

(9) When a bee larva dies of European foulbrood the decaying mass does not adhere closely to the cell wall at any time in the decay or when it has dried down to a scale in the back or on the side walls of the cell. Dead larvæ may therefore be removed easily by the bees if conditions are favorable for this cleaning.

(10) The bees are able under suitable conditions of colony strength and resistance to clean the cells so thoroughly that when future larvæ are reared in these cells the disease is not contracted.

(11) The method of spread of the disease is not well known, although there is some evidence that the infection is carried chiefly by nurse bees. It has been observed that under some circumstances it may be transmitted through feeding, but the experience of beekeepers indicates that contaminated honey is not the common means of carrying the disease. It is well known that honey from infected colonies may be given to healthy colonies with entire safety provided the healthy colonies are in such condition that they are able to resist the disease. It is therefore not necessary to disinfect the honey from colonies having European foulbrood, as is the case with that from colonies suffering from American foulbrood.

(12) It has not been found necessary to disinfect hives, combs, or frames from diseased colonies. This does not indicate that the germ causing the disease is absent from such material, but that if present it does not do any damage.

(13) While the disease spreads with great rapidity at times, it does not seem to be so malignant as is American foulbrood, since many colonies exposed to infection fail to contract the disease.

These facts concerning the disease have been discovered in the apiary rather than in the laboratory. The facts are supported by repeated observations, and while the records of observation are not as accurately made as are those of the laboratory the correctness of most

¹ *Bacillus pluton.*

of the facts is attested by the experience of hundreds of beekeepers. In certain cases the findings have been corroborated by bacteriological investigation.¹ The methods of treatment have also all been devised in the apiary.

The difficulty in drawing conclusions from practical observations is that too often beekeepers fail to show the ways in which their experience differs from that of others or in what manner the same principles have been applied in a slightly different manner.

PREVENTIVE MEASURES.

In keeping European foulbrood under control it is far more important to prevent the disease from getting a foothold in a colony than it is to eradicate the disease afterward.

This is not true of American foulbrood, for reliable and practicable preventive measures have not been found for that disease.

(1) The use of resistant stock is of the greatest importance, otherwise there is no hope of warding off the disease when it enters a region or of eradicating it from the apiary after it is once introduced. The use of strong, vigorous Italian stock is best from the standpoint of honey-production, and every beekeeper should therefore see that his apiary is provided with such queens even before European foulbrood appears in the immediate neighborhood or in the apiary. When the disease is absent it is quite permissible for the beekeeper to save any mismated queens which show themselves to be good, but when European foulbrood is near by this course is unsafe, and in no case should a mismated queen be used as breeding stock. The purity of mating of queens then becomes a matter of first importance and this entails more work than is necessary in the ordinary practices of the apiary.

It is not enough simply that queens be pure bred and purely mated, however, for it often occurs that a queen will be poor from other causes. Whenever a queen shows signs of failing it is good beekeeping to replace her with a good queen. When European foulbrood is present this becomes far more important.

Not all Italian stock is equally resistant to European foulbrood, and when the disease is nearby it becomes important that the beekeeper find out which stock is best. Not all queens sold as Italians are pure bred. By far the best plan is to buy a few untested Italian queens from each of several queen breeders and after these have been under observation for a short time the beekeeper will be able to choose from the lot those best suited for breeding purposes. It is not so good a practice to buy a breeding queen, for such queens do not ship

¹ Bacteriological studies have been useful in practical beekeeping in analyzing observations, serving to guide the observations of beekeepers in correct lines. They have been especially important in devising methods of laboratory diagnosis, so that it is possible to obtain definite knowledge of the presence of disease.

so well in the mails, and even a breeding queen of the most resistant stock might allow her colony to become infected simply because she had been so injured in the mails that she could not keep up egg-laying properly. The buying of untested queens is to be advised at all times, for until more accurate work in breeding is done the individual beekeeper can choose breeding stock as well as most breeders.

It would be possible to recommend certain stock as the best were it not for the fact that the stock of the various queen breeders is not constant. The stock which in one year makes the best showing possibly can not be duplicated by the queen breeders the next year. The best course therefore is for each beekeeper, or possibly a group of beekeepers, to try out several strains of Italian bees to find which is best. Having done this, they can continue to breed from the best stock obtained, and they can do as well by that means as they can if they continue to buy queens from the queen breeders.

(2) Strength of colony is fully as important as resistant stock. Unfortunately too many beekeepers fail to provide conditions necessary to the bees in order that the colonies may be at the proper strength in time to combat European foulbrood successfully. It is good beekeeping to have all colonies strong, and nothing leads to large honey crops as does this factor, yet throughout the country there are thousands of beekeepers who annually fail to get half the crop through failure to have strong colonies at the right time. When the honey-flow comes early in the season, as is the case throughout most of the United States, it is important that every colony be at maximum strength early in the spring. Since European foulbrood appears in the spring and early summer, good beekeeping practice again coincides with the requirements for preventing the ravages of this disease.

One difficulty arises from the fact that there is no standard for strength of colony and what one beekeeper considers a strong colony may be considered weak by another and better beekeeper. At the opening of the honey-flow every colony from which a full crop is to be expected should be strong enough to have 10 full combs of Langstroth size filled with brood. Of course this brood may be in a larger number of combs, since the bees usually store some honey at the top of each comb, but it is easy to estimate the brood in terms of full combs. If now we accept the same standard for the desired strength of colony for the purpose of resisting European foulbrood, we will have a condition under which (assuming resistant stock) this disease will never get a start in any colony in the apiary. It is of course recognized that such a standard is seldom realized before or at the beginning of the honey-flow, and this fact is the reason for the loss of so much honey as well as the full explanation of the ravages of European foulbrood in so many places. It is suggested that each beekeeper in a region where European foulbrood exists ask

himself whether his colonies are actually in as good condition at the opening of the year as he has supposed and that he find out how strong the colonies may be made by providing the best of conditions for the development of the colony population. A beekeeper whose colonies do not measure up to this standard should not condemn the standard until he assures himself that it is entirely impossible, under his conditions, to reach it.

Obviously the proper wintering of bees becomes a matter of the highest importance in regions where European foulbrood is found. Those who fail to practice good wintering are the ones who first lose so many colonies that they become discouraged and give up beekeeping, while those whose wintering has been better are able to treat the disease although their standard of colony strength may not be high enough entirely to ward it off.

As was pointed out earlier, the first brood of the year usually escapes with little loss. If proper conditions are provided for winter, either in the cellar or outdoors, brood-rearing is delayed, whereas in poor wintering brood-rearing may begin during the coldest period of the winter.¹ If then brood-rearing is delayed by protection, it will begin as a reaction to incoming nectar and pollen. The vitality of the bees has not been destroyed by unseasonable brood-rearing and the colony can rear large quantities of brood from the very beginning. This can, of course, occur only when the colony has proper spring protection. The earliest brood will emerge without appreciable loss from disease, the colony is increased in strength at once, and its capacity for brood-rearing is great. Provided the stock is resistant, the colony is then able to ward off the disease. To bring about all the proper conditions with the least labor on the part of the beekeeper and the least waste of effort on the part of the bees, it is desirable to winter outdoor colonies in two hive-bodies, which has been recommended by this department for other reasons also.

Good beekeeping, in so far as handling the bees is concerned, consists of providing conditions in the fall so that the colony is full of young, vigorous bees for winter; of providing conditions of protection and good stores such that the bees are not depleted in numbers and vitality during the winter by excessive heat-production; of providing plenty of stores, adequate room for breeding, and abundant protection during the period of heavy brood-rearing in spring; and of preventing reduction in the strength of the colony by swarming. All of these things, and there are no others of importance, pertain to keeping colonies strong. The beekeeper who provides conditions such that the bees can keep up their own strength will not only reap the honey-crop but he will escape the ravages of European foulbrood.

To a large degree the failure of American beekeepers to get their colonies strong enough is due to the use of small hives that are in-

¹ The explanation is given in the publications of the Bureau of Entomology on wintering.

sufficiently protected during the winter and spring. The single-walled hive was first made as a means of reducing the cost. Such a hive is a good tool for the beekeeper but it is a poor home for the bees. When the 10-frame hive was found too large to be filled with bees in time for them to go into the supers as soon as the honey-flow opened, instead of protecting the hive the use of the 8-frame hive was commonly adopted. This hive is in rather general use throughout the United States, although fortunately it is now being replaced by the 10-frame hive in many localities. In order that the beekeeper may reduce his labor, it would be well to raise the standard of colony strength by providing better protection and more room for the bees. This will to a large degree eliminate the spring manipulations so often practiced, will get better crops, and will make European foulbrood a minor trouble of the apiary.

REMEDIAL MEASURES.

When strong colonies headed by vigorous queens of resistant stock are present, European foulbrood will usually make little if any headway, yet from time to time there may appear cases which require treatment. The shaking treatment used for American foulbrood¹ is often advocated for European foulbrood and is recommended by many inspectors of apiaries. It was recommended in previous publications of this department, but later observations show that other methods are more reliable. If colonies are given young Italian queens at the time of shaking, results will usually be good, but unless this is done shaking is of little or no value. Some beekeepers practice heavy feeding of either honey or sugar sirup when European foulbrood appears. This often gives good results, for it brings about the conditions which are advocated as preventive measures, although as applied it constitutes a remedial measure. The same amount of stores left with the colony the previous fall will usually do more good than heavy spring feeding as a means of disease control.

The remedial measures here described should be used only to remove the disease if it enters the apiary. Preventive measures should then be employed to avoid a recurrence of the disease.

(1) The dead larvæ are easily removed from the cells, and the remedial treatment serves to provide conditions such that these may be removed by the bees during a period when no new diseased material is appearing in the combs. Usually the queen is removed from the colony, and, since a queen whose colony becomes badly infected is rarely of any value, she is killed. In five or six days all queen cells are removed, so that the colony is hopelessly queenless. The workers do not clean out the diseased cells so rapidly unless they have a queen

¹ For a description of this treatment the reader is referred to Farmers' Bulletin 442, "The Treatment of Bee Diseases."

or a queen cell. As soon as the dead larvæ are removed, which may be easily determined by examinations, the colony is given a young vigorous Italian queen of resistant stock. If only a few diseased cells are observed and if the colony is fairly populous the queen may simply be caged and released later when the dead brood is removed.

The length of time necessary for the cleaning out of the dead larvæ varies with the strength of the colony, and for weak colonies it may be necessary to wait until all brood has emerged before giving a young queen.¹ This method should not be employed unless each colony has enough bees to sustain at least five combs full of brood. Some colonies seem to clean out dead brood more rapidly than others of the same strength. If the honey-flow comes early it will usually be possible to reduce the period of queenlessness to a few days. A beekeeper may use the time necessary for cleaning up as an indication of the strength of his colonies, for if he finds a long time needed he may be sure that his colonies, for some reason, are not as prosperous as they should be. If it is certain that there will be no honey-flow until midsummer or later it is not so necessary, from the standpoint of good beekeeping, to have all colonies strong so early in the year, but it is surely an exceptional locality where there is nothing for the bees to get in early summer.

Where the beekeeper is dependent on a late honey-flow it is often desirable to move the bees during the early part of the season to some place where nectar may be obtained. This will often be easier and less expensive than treating the colonies. For example, the author was shown a location in the west where European foulbrood caused great annoyance during the spring, while apiaries not many miles away were able to get enough nectar to ward off the disease and at the same time to give the beekeeper enough profit to justify the expense and time of moving. In such a case preventive measures are cheaper and better than the remedial measures here described. Apiary inspectors should exercise judgment in such cases and permit the moving of colonies to such places, provided they are sure that due precautions will be taken. No precautions need be demanded if the new location is already infected.

¹ This method of treatment was described in its essentials in 1905, in an article published in a periodical devoted to beekeeping. The writer of that article advised that the colony be left queenless for three days after all drone-brood has emerged, thus making a queenless period of 27 days. Later other beekeepers tried shorter periods with success. It should be remembered that the apiaries belonging to the writer of the article referred to were located in the buckwheat region of New York, and that he used a small hive, and on account of these conditions it may be safely assumed that at the time when European foulbrood attacks colonies his colonies were unusually weak. Those who have found a shorter time sufficient have been located in regions where the colony strength may be developed earlier because of earlier honey-flows, or perhaps in some cases these beekeepers wintered better, so that in the spring their colonies were in better condition to resist the ravages of the disease. It would be quite possible to refer to apiaries where the wintering is good and where the spring care is sufficient to eliminate entirely the period of queenlessness.

The methods of requeening and rearing the queens are matters aside from the treatment of European foulbrood, but in many cases the directions have been obscured by including all such details. Usually it is easier to introduce a queen-cell of the proper age for the queen to emerge and mate by the time egg laying may again proceed safely in the colony.

(2) A substitute for the treatment just described introduces no new principle. The colonies found to have European foulbrood are graded according to strength, and half or more of the stronger ones are shaken to dry extracting combs (not comb foundation) at the same time that the old queens are killed and replaced by young, vigorous stock. No colony too weak to have five frames of brood should be so treated. If there is no honey coming in, the combs may contain some honey, and it is immaterial whether or not it comes from a colony having European foulbrood. The removed brood is now stacked on the weaker diseased colonies so that they may be increased in strength. Just as soon as these have reached the degree of strength possessed by the first colonies shaken, they, too, may be shaken to drawn combs containing no brood, and the diseased brood is given to the remaining few diseased colonies. Usually by the time that the last colonies are ready for treatment it will be found that treatment is not necessary, for in many cases the dead brood will have been removed. If necessary, of course, every diseased colony may be treated.

This substitution for the more usual method of treatment has certain advantages. No colony is left queenless and, as a result, the total brood reared in the apiary is increased. No brood is wasted, and the colonies which receive the most of the combs containing diseased brood are usually made sufficiently strong to gather a good crop.

(3) Another method which is much used is to place all the brood combs of the infected colony except one in the second hive body over a queen-excluder and to place the queen below with the one frame of brood and frames containing foundation or even drawn combs. Others prefer to put the queen and one frame of brood above. Of course only good Italian queens should be used.

It is interesting to note that the methods used in the control of European foulbrood are exactly the same as are used in remedial methods for swarm control.¹ Either the queen or the brood is removed or the queen and brood are separated within the hive. Such a similarity is probably of significance, but this at present is merely a matter of speculation.

GOOD BEEKEEPING WILL ERADICATE THE DISEASE.

It can not be emphasized too strongly that the practices of good beekeeping are those which result in the eradication of European

¹ See Farmers' Bulletin 503, "Comb Honey."

foulbrood. It does not follow that because a beekeeper is troubled with European foulbrood he is a poor beekeeper, for he may have had good results before the disease appeared. With the entrance of the disease, however, he can change his system so as to overcome the trouble and he may do this with assurance that the changes are such as to result in good beekeeping. Unlike American foulbrood, the disease does not make it necessary that anything of value be destroyed by the beekeeper, and if the proper system of management for the particular locality can be found it will result, in most circumstances, in larger crops than are usually obtained.

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